FEDERAL REPUBLIC OF NIGERIA

Annual Report on the Department of Agricultural Research

For the Year 1960 - 61

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FOREWORD

It is an incontrovertible fact that the development of any nation depends in no small measure on its ability to feed its people. This can be achieved either by importation or local production of foodstuffs. Traditionally, Nigeria is an agricultural country and in the past has depended almost entirely on agriculture both for cash crops for export and food crops for consumption. In the present era of rapid economic development of our newly independent country much emphasis has been given to the establishment of industries. But industrialisation entails urbanisation, frequently at the expense of agricultural land, and certainly results in a drift of labour from the land to the factory. The responsibility of feeding new urban populations and also of coping with an already rapidly increasing population thus lies in the hands of relatively fewer people. It is clear therefore that our farmers and those whose duty it is to aid the farmer, must work untiringly towards the goal of increased production. Not only increased production through the utilisation of greater acreages but increased production from each acre of agricultural land.

This report indicates clearly that the Federal Department of Agricultural Research, charged as it is with the improvement of local staple foodstuffs, is continuing valuable fundamental work in the production of improved, high yielding, disease resistant varieties of maize, rice and root crops; on the early recognition of plant nutrient deficiencies and on essential studies of the biology of insect and other pests attacking crops. It is encouraging to note that many Nigerians are now being recruited for specialist training in the skill required for the work of the Department, and that some are already in service. Plans have been laid for the Department's place in the new five-year development plan and it is my earnest hope that the acceleration of the promulgation and practical application of research results may be achieved.

Waziri Ibrahim, M.P.,
Ministry of Economic Development

CONTENTS

	Page
Staff List	5
Report by the Director	7
Progress in Research :	
Plant Physiology	14
Root Crops	18
Maize	24
Legumes	27
Tree Crops	31
Rice	32
Plant Pathology	42
Plant Quarantine	47
Horticulture	49
Entomology	49
Quelea	66
Striga	67
Library and Publications	67
Meteorological Records	69

STAFF LIST AS AT 31ST MARCH, 1961

MOOR PLANTATION, IBADAN

Director of Agricultural Research ...	J. M. Waterston, B.Sc., Ph.D. (Edin.). F.L.S., A.I.C.T.A.
Higher Executive Officer	S. B. Alalade
Senior Accountant	R. J. Luton
Executive Officer (Accounts) ...	M. O. Ojekwe
Records Officer	M. I. M. Smith, B.Sc. (St. Andrews).
Agronomists	P. M. Chinwuba, B.A. (Calif.), B.Sc. (Lincoln), M.Sc. (Miss.).
	G. P. Tewari, B.Sc., M.S., Ph.D. (Minnesota).
	Th. van der Feijst, L.i. (Wageningen).
Botanists	C. L. M. van Eijnatten, L.i. (Wageningen).
Chemist	M. N. Nwaji, B.Sc. (Lond.).
Agricultural Chemist	M. N. Okafor, B.Sc. (Lond.).
Statistician	B. Afonja, B.Sc. (Lond.).
Librarian	N. I. Shinie, B.Sc. (Edin.), A.L.A.
Entomologists	F. A. Squire, B.Sc. (Rhodes), A.I.C.T.A.
	L. A. Mound, B.Sc. (Lond.), D.I.C., D.T.A., F.R.E.S., A.L.S.
Mycologists	A. G. Bailey, B.Sc. (Lond.), D.A.S., D.T.A., M.I. Biol.
	S. A. Anibaba, B.Sc. (Lond.).
Plant Pathologist	D. G. Robertson, B.A. (Oxon.), D.A.S.
Plant Physiologist	R. Spencer, B.Sc. (Lond.).
Technical Officers	M. J. Ekandem
	J. K. Olurin
	N. N. Okparanta
	J. A. Obi
Laboratory Technologists	S. N. Muotoe
	S. B. Bernard
Station Manager	W. A. Porter, N.D.A., C.D.A. (Glasgow).

BADEGGI SUB-STATION

Botanists	J. E. Y. Hardcastle, B.Sc. (Dunelm), D.A.S., D.T.A.
	B. D. A. Beck, B.Sc., D.T.A., D.A.S.
	J. A. F. M. Sluyters, M.Sc. (Wageningen).
	F. C. Bent, Ph.D. (Cornell).
Agronomist	T. J. Bredero, B.Sc., M.Sc. (Wageningen).
Station Manager	S. A. Soremi

UMUAHIA

Botanist	... ...	A. W. Waitt, B.Sc. (Edin.), D.A.S., D.T.A. J. L. Gregory, B.Sc. (Sheffield), D.A.S., D.T.A., F.R.E.S.

SAMARU

Entomologist	... ...	K. M. Harris, B.Sc. (Wales), D.A.S., D.T.A.

CALABAR PLANT QUARANTINE STATION

Technical Officer	... ...	A. O. Bamtefa

KANO PLANT QUARANTINE STATION

Technical Officers	... ...	E. A. Dosunmu E. D. Oddy. Dip. Hort. (Wisley).

RESEARCH FELLOWSHIPS

Name	*Place of Tenure*	*Subject*
P. Ward, B.Sc. (Liverpool)	University College, Ibadan	Quelea Investigations
C. N. Williams	University College, Ibadan	Striga Investigations

ANNUAL REPORT ON THE DEPARTMENT OF AGRICULTURAL RESEARCH, FEDERATION OF NIGERIA, FOR THE YEAR 1960-61

REPORT BY THE DIRECTOR

Introduction

There were no major changes in policy during the period under review. The main lines of investigation continues to be concerned with the improvement of food crops including studies on the factors affecting soil fertility and crop nutrition as well as the control of disease and pests. It is heartening to record an increasing awareness by the public of the role which agriculture should play in the development of the industrial economy of Nigeria. Some years ago Professor Lewis, the eminent African Economist, emphasised "the most certain way to promote industrialisation is to lay the foundations it requires by taking vigorous measures to raise food production per person in agriculture". This was recently endorsed by Lord Netherthorpe* who said that in his view "agriculture is the key to the prospect and rate of Nigerian industrialisation." He also stressed the need not only to step up research efforts but also to extend advisory services together with experimental husbandary and demonstration farms.

Among the many far reaching proposals contained in the Ashby Report† which appeared during the year under review, reference was made to the fostering of agricultural research as follows :—

"Though agricultural production in Nigeria can most assuredly be increased by using improved practices already known real progress cannot be made until research workers have the answer to a myriad of questions ranging from farm management and rotation systems to insect and plant disease control. As a matter of fact, the teaching of agriculture will be far too sterile until a build-up of information makes better teaching possible. It is urged therefore that the Federal Government do a number of things about agricultural research including:

(1) Establishment of additional stations to carry on fundamental research, co-ordinated with appropriate West African research institutes and with Regional and university research programmes and aimed at major problems. A workable scheme for Federal Government involvement is contained in Sessional Paper No. 4 of 1959, a report by Sir Frank Engledow, on the Federal organisation for agriculture, veterinary, forestry, and fisheries research.

(2) Appropriating funds for university and Regional research.

(3) Financing training abroad for selected research workers.

(4) Seeking outside assistance from agencies such as Food and Agriculture Organisation and International Co-operation Administration."

* Kipping *et al* (1961) Nigeria—An Industrial Reconnaissance (p. 29).
† Ashby *et al* (1960) Investment in Education—Report of the Commission on Post-school Certificate and Higher Education in Nigeria (p. 192).

These recommendations are at present being studied by Government which established a Standing Committee on Agricultural Policy in September 1960 under the aegis of the National Economic Council. Their terms of reference are to promote a closer co-ordination of research activities with agricultural policies within the Federation with special emphasis on the need for more effort to put research results into practice.

Staff

The shortage of professional staff continued to be a serious limiting factor in the progress of the Department's research activities. It is however, encouraging to report that five Nigerians have now been appointed as Specialist Officers.

It is with deep regret that we have to record the death of Mr P. E. Udeaja in December 1960, after only two years service as Plant Nematologist. Mr Udeaja was the first Nigerian specialist officer to be appointed to this Department and his loss will be keenly felt.

The following four new recruits appointed included three Nigerians :— Miss S. A. Anibaba, Mycologist, Mr M. N. Okafor, Chemist, Mr B. Afonja, Statistician and Miss N. I. Shinie, Librarian.

As a result of these staff changes the total strength of professional staff increased to 23 as shown in Table I, and was the highest reached during the ten year period under review.

The authorised establishment of senior staff at the beginning of the year and the actual strength at 31st March, 1961 are given below. It will be noted that there was a total of 28 vacancies in our establishment of 80. This is an improvement over the previous year.

Professional	*Authorised*	*Actual*
Director	1	1
Deputy Director	1	—
Principal Research Officers	5	2
Senior Specialists and Specialists	33	18
Scientific Officers (Soil Fertility Unit)	2	—
Librarian	1	1
Total Professional Staff	43	22

Higher Technical Staff	*Authorised*	*Actual*
Technical Officer	6	6
Assistant Technical Officers	11	11
Laboratory Technologists	3	2
Assistant Laboratory Technologists	5	1
Station Managers	2	2
Total Higher Technical Staff	27	22

Executive	*Authorised*	*Actual*
Senior Accountant	1	1
Higher Executive Officer	1	1
Executive Officers	2	2
Assistant Executive Officers	4	3
Records Officer	1	1
Personal Secretary	1	1
Total Executive Staff	10	8
Grand total Senior Staff	80	52

The corresponding position for Junior Staff at 1st March, 1961 showed a total of 55 vacancies in an establishment of 236 as follows:—

Clerical	*Authorised*	*Actual*
Chief Clerk	1	1
Assistant Chief Clerk	2	2
First Class Clerks	9	9
Second and Third Class Clerks	27	17
Stenographer	1	1
Library Assistants	2	2
Total Clerical Staff	42	32
Technical		
Senior Agricultural Assistants, Grade I	1	1
Senior Agricultural Assistants, Grade II	6	2
Agricultural Assistants, Grades II & III	55	38
2nd and 3rd Class Agricultural Laboratory Technicians	6	1
Photographic Assistants, Grade I	1	1
Draughtsman, Grade II	1	1
	79	48
Minor Technical and Clerical (Scale F)		
Senior Field Overseers	6	5
Field Overseers, Grades I and II	56	48
Artisans	10	10
Driver-Mechanics	6	6
Clerical Assistants	10	8
Typists	8	7
Meteorological Recorders	1	1
Total Minor Technical and Clerical Staff	97	85

Sub-clerical and Minor Technical	*Authorised*	*Actual*
Laboratory Attendants	6	5
Telephone Attendants	3	2
Messengers	9	9
Total Sub-clerical and Minor Technical ...	18	16
Grand Total Junior Staff	236	181

As will be seen below, there are at present 233 substantive holders of posts in our establishment of 316 leaving 83 vacancies.

PROGRESS OF NIGERIANISATION AS AT 31ST MARCH, 1961

	Nigerian	*Expatriate* (*p*)	*Expatriate* (*c*)	*Vacant*	*Total*
Professional	5	7	10	21	43
Higher Technical	20	—	2	5	27
Technical	48	—	—	31	79
Minor Technical	85	—	—	12	97
Executive	5	—	3	2	10
Clerical	32	—	—	10	42
Sub-clerical	16	—	—	2	18
Total	211	7	15	83	316

(*p*) = pensionable. (*c*) = contract terms.

PROGRESS IN RESEARCH

The following is a summary of the progress made with research projects during the year. Fuller details are contained in a later part of this report.

Crop Nutrition.—Studies were continued by the Plant Physiologist on the techniques required for evaluating the nutritional requirements of food crops. A start has been made with cassava and maize.

These studies when completed will enable a better understanding of the problems involved in the maintenance of soil fertility and the proper use of fertilizers.

Improvement of food crops.—The aim of the food crop improvement research programme is to produce superior varieties which combine inherently high yields with disease and pest resistance. Very good progress has been made in this direction by the plant breeders with maize, rice and cassava. Other crops being studied include yams, sweet-potatoes, cowpeas, citrus and kola.

Control of diseases and pests.—Studies were continued on virus diseases affecting cowpeas and a further new disease was recorded. Entomological work included studies on cereal stem borers ; the biology and control of yam beetles ; stem borers attacking cola and coffee ; and population studies on white flies, aphids and psyllids.

The Plant Quarantine Service had an active year and dealt with a large number of plant importations which included two valuable consignments of sugar cane destined for Bacita.

Research Fellowships.—The research fellow for studies on plant pests (witch-weed, *Striga* spp.) was engaged on investigations into the physiology of parasitism with a view to the development of agricultural practices designed to control this weed. The research fellow on *Quelea* birds made a useful start on the biology and feeding habits of these pests.

Visiting Mission

A team of three experts from the Rubber Research Institute, Malaya, Mr C. W. Brookson, Head of the Botanical Division, Mr J. E. Morris, Advising Officer, Chemical Division and Mr Wong Mun Fun, Assistant Smallholder Advising Officer, visited all three regions in the Federation, as well as the Western Cameroons from October to December 1960.

The terms of reference of the mission were to advise on what rubber research was required in Nigeria and the manner in which it should be conducted. A very thorough survey was carried out by the mission but no report was received during the period under review.

Conferences

The first regional F.A.O. Conference for Africa was held in Lagos, 3rd to 12th November, 1960 and which 18 member Governments attended and 15 other countries and organisations participated as observers.

The conference stressed that one of the basic needs of economic development in Africa was to change from merely subsistence-level farming methods to large-scale production systems.

The problems of shortage of qualified personnel and capital required to implement this policy were discussed as well as ways and means for staff training and the supply of bilateral and international financial assistance. The conference also took note of the special need for economic and nutritional factors to be taken into account when formulating food and agricultural policies. The need to diversify agriculture combined with a second system of crop rotation based on intensive farming using fertilizers and improved husbandry, was also emphasised.

The conference also recognized the need for active participation of the population if rural progress was to be achieved.

The West African Service Association held a successful conference at the University College, Ibadan, on 16th to 21st December, 1960, problems discussed including production and agricultural techniques.

Meetings of Research Workers

Although no meeting of the Council of Natural Resources was held during the year under review, the Agricultural Technical Committee continued to function and held its 8th Meeting at Samaru on 12th-16th May, 1960 when research progress in the Federation was reviewed.

The research seminars held at regular intervals at Moor Plantation, were well attended by members of the Department of Agricultural Research, the Western Region Ministry of Agriculture and Natural Resources, the West African Cocoa Research Institute, the University College, Ibadan, and visiting scientists from the International Development Services.

Interterritorial Research Committees

Meeting of the Management Committees and Technical Sub-committees of the West African Cocoa Research Institute, the West African Institute for Oil-palm Research and the West African Rice Research Station were regularly attended and the needs of all Regions kept in view.

Distinguished Visitors

The Department was honoured by the following distinguished visitors to its headquarters:

Viscount Head, United Kingdom High Commissioner.
Miss E. L. Dulles, Department of State, Washington, D.C.
Mr Joseph Palmer, American Ambassador.
Sir Robert Aitken, Overseas Research Council.
Mr John J. Mackelvey, Jr., Rockefeller Foundation.

Visitors to the Rice Research Station, Badeggi, included: His Excellency H. A. S. Johnston, C.M.B., O.B.E., D.F.C., Officer Administrating the Government of Northern Nigeria; Alhaji Koguna, Parliamentary Secretary to the Ministry of Pensions; Mallam Ibrahim Galadima, Federal Parliamentary Secretary, Ministry of Establishments, and Alhaji Muhammadu Ndyako, Etsu Nupe.

Interchange of visits by agricultural research specialists to neighbouring regions and territories

Dr J. M. Waterston, Director of Agricultural Research visited Ghana in September 1960 to see the Ministry of Agriculture Research Headquarters at Kwadoso, Kumasi.

Scientists visiting Nigeria included Mr O. W. Snow, Chief Scientific Officer, Ministry of Agriculture, Ghana; Mr C. A. Dady, Chief Agricultural Officer, Ghana; Dr Charles P. Hoyt, South Pacific Commission, Noumea, New California; Messrs C. W. Brookson, J. Morris and Wong Mun Tun, Rubber Research Institute, Malaya; Dr P. R. Hesse, West African Rice Research Station, Rokupr, Sierra Leone; Mr L. J. Marenah, Department of Agriculture, Gambia; Mr Nigel Hesseltin, F.A.O. Liaison Officer for Africa; Mr K. Satrap, U.N.T.A.B., Accra; Dr N. Parthasarathy, F.A.O. Rice Improvement Specialists; Dr G. Julen, F.A.O. Plant Breeding Specialist; Dr A. B. Fagunde, F.A.O., Rome; Mr Hugh R. Richwine, I.C.A., Lagos; Dr V. C. Johnson, I.C.A., Lagos; Dr L. N. Wise, I.C.A., Missouri State University; Dr D. W. Hedrick, I.D.S., Pasture Research Officer; Dr F. Simmonds, Director, Commonwealth Institute of Biological Control, Ottawa; Mr L. Horton, Tropical Products Institute, London; Dr M. H. Barat, Secretary, I.A.P.S.C., London; Mr C. L. Skidmore, Commonwealth Agricultural Bureau; Dr W. F. Stolper, Ministry of Economic Development, Lagos; Dr G. Watts Padwick, Plant Protection Limited, England, and Mr R. C. Ogley, Department of Political Economy, Edinburgh University, Scotland.

Nigerian Exhibition

The Department contributed an exhibit which was part of a display of Natural Resources research prepared under the aegis of the Ministry of Economic Development for the Nigeria Exhibition held in Lagos on 30th September to 22nd October, 1960. Mr M. J. Ekandem was in charge of the Department's display which was staged in the Hall of Prosperity in the Federal Government Pavilion.

Other research organisations co-operating in the exhibit included the Departments of Fisheries, Forestry and Veterinary Research, the West African Institute for Oil Palm Research, the West African Cocoa Research Institute and the West African Institute for Trypanosomiasis Research.

Very favourable comments were received from visitors to the exhibit which included Her Royal Highness the Princess Alexandra who opened the Exhibition on 30th September.

J. M. WATERSTON,
Director of Agricultural Research

PROGRESS IN RESEARCH
Plant Physiology

Crop Nutrition (Mr R. Spencer)

No further attempts were made during the year to produce deficiency symptoms in sand culture owing to difficulty in obtaining sufficient purified sand.

The component parts of an ion-exchange system have arrived and these will be assembled on the completion of the working shelter. A large underground storage tank capable of holding 5,000 gallons of rain water has been built adjacent to the working shelter. On passing the rain water through cation-anion-cation-anion-mixed bed columns in series, it is hoped that the conductivity of the effluent will be of the order of $0.2 \times 10-6$ mhos. A Keebush sand digester is on order and this will facilitate the purification of large quantities of sand. When this equipment is assembled and in working order, further attempts will be made to produce deficiency symptoms of the major and minor elements in yams, cassava, rice and certain legumes.

A small commercial deionising unit was purchased during the year to provide sufficient purified water for plant analysis and for some water culture studies. A small preliminary experiment was carried out to determine whether maize and cassava would grow together in water culture. Maize variety 'Trinidad Bulk' and cassava variety 53101 were germinated in soil blocks, and five seedlings of each were transferred to polythene bowls holding four litres of nutrient solution. The plants were supported by cotton wool plugs in one diameter holes drilled into plywood lids. Seven treatments were given in duplicate as follows:—(*i*) complete nutrient; (*ii*) complete nutrient minus nitrogen; (*iii*) complete nutrient minus phosphorus; (*iv*) complete nutrient minus potassium; (*v*) complete nutrient minus calcium; (*vi*) complete nutrient minus magnesium and (*vii*) complete nutrient minus sulphur. The solutions were made up according to Hewit's method (Tech. Comm. No. 22 Commonwealth Agricultural Bureau of Horticulture and Plantation Crops, East Malling, 1952). Treatments with nutrient minus calcium and minus potassium did not grow well for the first 14 days owing to the apparent death of the roots. After this time new roots were formed, but it was realised that owing to the desiccation of the plants and the death of many leaves, characteristic deficiency symptoms would not be produced unless there was considerable new growth. Characteristic deficiency symptoms of nitrogen, phosphorus, potassium and magnesium were produced on maize, but the plants in the calcium treatments did not recover from their initial set back and no new leaves were produced. The absence of symptoms associated with sulphur deficiency would seem to indicate that maize has a fairly low requirement of this element.

The cassava plants did not respond at all well to the treatment, relatively little or no new growth taking place. This could be explained by the fact that the maize made very rapid initial growth with consequent heavy demands on the nutrient supply. This occurred despite the weekly, and later twice weekly, renewal of the nutrient solutions. At harvest, the maize roots occupied most of the volume of the bowls.

Typical symptoms of nitrogen deficiency were produced with an overall paling of the leaves and a general reduction in growth. The symptoms increased in severity, with the older leaves becoming completely chlorotic prior to abscission. Magnesium deficiency symptoms were also produced. These began with a paling

of the interveinal areas of the older leaves, and as the severity of the symptoms increased, these became chlorotic islands surrounded by green bands along the veins. Colour transparencies were taken of the deficiencies produced to assist in future diagnostic work. It is proposed to repeat the experiment with cassava in monoculture.

Plant Analysis Studies.—Fresh tissue tests have been used by many workers, particularly Nicholas, as a quick method of diagnosing the nutrient status of plants. It is essential however to correlate these with other diagnostic methods, for example with chemical analysis of plant ash or soil nutrient status. To discover if there was any correlation between the nutrient content of maize determined by fresh tissue tests and by a full chemical analysis of the plant ash, the leaves of the maize plants from the water culture experiment were cut longitudinally down the midrib, one half being used for chemical analysis and the other for tissue tests. The fresh tissue tests were carried out according to the methods of Nicholas (J. Hort. Sci. 1948, *24*, No. 2, 72-122). Correlations between the two methods were obtained for potassium (significant at the 5 per cent level), nitrogen (significant at the 1 per cent level) and magnesium (significant at the 0.1 per cent level). Had more results been available, it is possible that there would also have been correlations for calcium and phosphorus, and in addition, the correlations for nitrogen, potassium and magnesium might have been more significant.

A further experiment was laid down to obtain more results. 'Trinidad Bulk' was sown into unpurified sand and each of the major elements was applied at three levels (*a*) complete (*b*) half complete level (N/2, K/2, etc.) and (*c*) deficiency level (*e.g.* N/O, K/O, etc.). The growth of the plants was extremely poor, which could possibly be attributed to the low light intensity conditions prevailing in the glasshouse. The plants also suffered much insect damage, and consequently very few samples were available for analysis. The results from the seven samples which were available increased the significance of the correlations for nitrogen, potassium and magnesium, all being significant at the 0.1 per cent level. There were still no significant correlations for calcium and phosphorus. Before any definite conclusions can be drawn, more analysis will have to be carried out.

In the wet ashing of plant material with a mixture of nitric, perchloric and sulphuric acids, the time taken for the digest to clear has been reduced from five hours to between one and a half to two hours by using 250 ml beakers covered with a watch glass in place of the 300 ml kjeldahl flasks. The use of beakers also facilitates the transfer of the digest to the 100 ml volumetric flasks.

Leaf Washing Trial.—Prior to leaf analysis, it is important that all surface contamination, arising particularly from dust and agricultural sprays, be removed. Instructions in the literature for the removal of the surface film vary from no washing to washing with distilled water, dilute acids and soap solutions. In order to determine the best method for cleaning cassava leaves, a large pile of leaves of the variety Congo was thoroughly mixed and divided into four lots. Each lot was further subdivided into three batches with one of the following washing treatments applied to each batch: (*a*) no washing (*b*) washing in demineralised water with a pad of cotton wool and (*c*) washing in a 0.2 per cent teepol solution with a pad of cotton wool. After washing, the leaves of treatments (*b*) and (*c*) were well rinsed and blotted dry. All samples then received the same drying, grinding, ashing and analytical treatments. Although there was a slight reduction in the potassium content through washing, this was not statistically significant. As potassium is one of the most easily leached of the plant nutrients, it seems unlikely that other less soluble nutrients will be removed by washing. This is

borne out by the results. The only element to be reduced significantly (0.1 per cent level) by the washing treatments was iron, there being no difference in effectiveness between water and teepol. The major contamination on leaf surfaces is from iron, particularly in lateritic soils, and if this contaminant can be removed, this is indicative of an efficient washing technique. Both washing treatments reduced the iron level of the sample by 70 per cent compared to the control, and it is surprising to note that water is as effective as a soap solution in removing the surface dirt film. Water will now be used as the routine washing agent for cassava leaves.

Leaf Drying Temperature.—An important consideration during the drying of leaf material prior to analysis is that the temperature should be sufficiently high to stop enzymatic action and dry the material in the shortest possible time but it should not be so high that it causes scorching and thermal decomposition. To find the optimum drying temperature for cassava, a large batch of leaves of the variety Congo was washed in demineralised water and divided into four groups after thorough mixing. Each group was then subdivided into four samples, placed in muslin bags and each sample was dried at one of the following temperatures—(*a*) 50°C (*b*) 60°C (*c*) 80°C and (*d*) 105°C. After drying, each sample was ground, stored in a glass bottle, and prior to analysis, was dried at 105°C for sixteen hours. During each stage of the experiment, the colour of the leaves and the leaf powder was noted using a Munsell colour fan. At no temperature was there any sign of scorching, and there was very little, if any, change in colour. There were no significant effects due to treatment, and as no scorching occurred at 105°C, this has been chosen as the routine drying temperature.

Leaf Area Determination of Cassava.—The punch disc method of Watson M. and Watson D.J. (Ann. Appl. Biol. 1953, *40,* No. 1, 1) has been used by Chant (University of Edinburgh Ph.D. Thesis, 1958) to determine the leaf area of cassava. An investigation was carried out to determine the accuracy of this method. The area of 15 individual cassava leaves was measured by the punch method, by planimeter and by a grid with squares of 1 cm^2. The results are summarised in Table 1.

TABLE 1.—MEAN AREA (CM^2) OF FIFTEEN CASSAVA LEAVES BY THREE METHODS AND THE PERCENTAGE ERROR OF THE GRID AND PUNCH METHODS OVER THE PLANIMETER METHOD

Method	*Planimeter*	*Grid*	*Punch*
Area (cm^2)	170.9	175.8	200.0
% Error	—	+2.87	+17.03

Although the percentage error of the punch method is high, it must be pointed out that the discs were not taken from a large batch of leaves as recommended by Watson and Watson. A large batch of leaves was therefore arranged in several layers in a tray and discs of 0.568 cm^2 cross sectional area were removed at random. The area of the leaves was determined by counting whole discs only and then by counting all discs more than half complete. The total area of the leaves was checked using the grid. The results are shown in Table 2.

TABLE 2.—AREA (cm^2) OF A BATCH OF CASSAVA LEAVES DETERMINED BY THE GRID AND PUNCH METHODS AND THE PERCENTAGE ERROR OF THE PUNCH METHODS OVER THE GRID METHOD

Method	*Grid*	*Punch*	
		Whole discs	*All discs more than half complete*
Area (cm^2)	4486.0	4763.3	5128.9
% Error	—	+6.2	+14.3

This demonstrates that the accuracy of the punch method is improved by sampling a large batch of leaves and by ignoring all incomplete discs. The error is however still high (greater than 6 per cent), the method is very time-consuming, and subject to errors in counting out discs, and is therefore not suitable as a routine method.

It has been found that the length/greatest breadth ratio (L/B) of the median leaflet is remarkably constant for a particular variety. Most of the varieties investigated having a ratio of between 3.2 and 3.9. When the leaf area of a particular variety (cm^2), determined by planimeter, was plotted against the leaflet rectangle area (L.R.A.) (cm^2), obtained by multiplying the product of length and greatest breadth by the number of leaflets on the leaf, a very highly significant positive correlation was obtained ; the steepness of the slope of the regression line being related to the L/B ratio as shown in Table 3.

TABLE 3.—RELATIONSHIP BETWEEN THE REGRESSION OF LEAF AREA ON L.R.A. AND THE L/B RATIO

Variety	*Regression equation*	*L/B Ratio*
58389	$Y = 2.64X - 70.96$	3.63
59401	$Y = 2.44X - 20.08$	3.33
Congo	$Y = 2.18X + 16.95$	3.29
58249	$Y = 1.02X + 300.9$	2.79

The regression line for Congo was found to give a very good estimate of leaf area for the narrow waisted varieties, but not for the broader variety 58249. This is shown in Table 4.

TABLE 4.—MEAN LEAF AREA (CM^2) OF FOUR CASSAVA VARIETIES DETERMINED BY PLANIMETER AND BY THE REGRESSION OF LEAF AREA ON L.R.A. FOR CONGO AND THE PERCENTAGE ERROR OVER THE PLANIMETER METHOD

Variety	*Planimeter Area (cm^2)*	*Regression Area (cm^2)*	*% Error*
Congo	160.37	159.42	— 0.6
59401	185.22	189.42	+ 2.3
58389	268.23	269.57	+ 0.5
58249	187.41	211.54	+12.9

As can be seen from Table 4, the regression line for Congo can be used for varieties with L/B ratios between 3.2 and 3.7 to give a good estimate of leaf area. For varieties with L/B ratios outside this range, a separate calculation must be made and a new graph drawn. This method, which is fairly rapid, gives accurate results and will be used for future leaf area determinations of cassava.

Growth Analysis of Cassava.—The data from this experiment has now been collected and is awaiting statistical analysis. However, some observations can already be made. From the nutrient content figures and dry weight yields, it has been calculated that after eighteen months growth, a crop of Congo with a density of 3,630 plants per acre, yielding 14.4 tons fresh weight of tuber, would remove the following amounts of nutrients from the soil (lbs/acre) :—N 154 ; P_2O_5 64 ; K_2O 299 ; CaO 156 ; MgO 49. From these figures, it is obvious that if successive crops are to be supported without reverting to fallow, considerable amounts of artificial fertilizers must be added after each crop.

For the first four months of growth, nitrogen is the element taken up in greatest amounts. This is presumably on account of the rapid growth and formation of new tissues which takes place in the early stages of growth. After this time, the uptake of potassium increases rapidly, and had not begun to fall off at the end of the experiment. Surprisingly enough, cassava has a high calcium requirement, the curve of uptake with time being almost linear and running closely parallel to the nitrogen curve for the last six weeks. The uptake curves of magnesium and phosphorus were both very similar and showed no peaks of maximum uptake.

After the first five sampling periods, the leaf area per plant was extremely variable and this caused several anomalies with apparent reductions in leaf area between some intervals. Consequently, net assimilation rates cannot be calculated after the fifth sampling. This experiment is to be repeated this year, both in drums with five plants per sample and in the field with ten plants per sample. This will provide an interesting comparison between the growth of cassava in the field and under conditions of a relatively confined root system.

BOTANY

Yams (Mr A. W. Waitt)

Collection.—Further additions to the National Yam Collection have been made from within Nigeria. The Botany Department, University of Ghana also kindly sent specimens from their *Dioscorea* Collection. Unfortunately due to the delay in transit a few of the tubers and all the seeds failed to germinate.

Eleven species of *Dioscorea* are included in the collection now centred at the Federal Root Crop Research Unit, Umudike. The material will be used in the phylogenetic study of the genus and incorporated in the breeding programme of the cultivated species.

Further investigations have been made on the classification of species and varieties. Observations have been repeated on tuber characteristics and only a few characters have been found to remain constant under a variety of environmental conditions. Physical soil differences appear to create the greatest variation of a character within a clone. Variable characters include prickliness, lobing, roughness of skin and to a lesser degree shape.

Measurements as well as subjective observations of vines, stem and branch leaves have been taken. Attempts to separate varieties by statistical means have not been successful. Species and sub-species differences can be detected by this method but, by itself it is not sufficiently sensitive. The classification requires the use of subjective observations at different stages in the growth of the plant to support the statistical separation. This work is being continued.

A great deal of importance is being attached to this problem of the classification of the cultivated *Dioscoreas*. As well as being important to the field worker a successful method of classifying yams is very necessary for the extension of the breeding programme.

Regional Trials.—Materials in the collection is multiplied and used for agronomic and regional trials. When sufficient material becomes available it is put into collection at chosen sites in the middle and south of Nigeria—the main yam growing areas. The choice of site is based primarily on ecological differences and collections have been established at nine such sites. Clones at these sites supply information on yield and the possible variation in the morphology of vines and tubers due to different environmental conditions. Clones which give a low average yield, based on the yield of forty stands, are withdrawn and replaced by other clones from the central collection. Results to date suggest that it will be possible to increase the local yield of yams ; however, statistical yield trials must be carried out on these collections to confirm this and these cannot be carried out until there is sufficient clonal material.

Experimental taxonomy.—In this work chromatographic techniques have been used to investigate the polyphenols present in the leaves of the various species in the collection. The results do not wholly support the classification presented by herbarium taxonomists. This work is being continued.

Flower induction.—It has been stated in previous reports that one of the main hazards in trying to carry out a breeding programme on yams is the irregularity of flowering. This difficulty has been found in other crops which are vegetatively propagated but in most cases methods such as grafting and chemical treatments, have been used to induce flowering. None of these techniques has been successful when tried on yam.

Two experiments were laid down this year to study the effect of time of planting and sett weight on the flowering of yams. Planting was carried out in January and April and sett weights of two, four and eight ounces were used of flowering and non-flowering clones. Heads, middle and bottom setts were planted separately. Time of planting had no effect on flowering ; but the eight ounce setts gave a higher percentage of flowering stands and setts taken from the head of the tuber were superior to those taken from the middle or bottom.

Sett weight and planting distance.—As far as is known no satisfactory study has been made on the optimum sett weight (seed rate) and spacing distance (population density) for different types and species of yams. This study, fundamental for each agricultural area, has been badly neglected.

Experiments were begun on Moor Plantation using available material of one clone each of White and Water yam. In the respect of *D. rotundata,* four, eight, twelve and twenty ounce setts were planted at two, three, four and six foot spacings on three foot ridges except at two and four foot spacings where there was insufficient material to plant twenty ounce setts.

Analysis of germination and yield records show that 16 ounce setts were superior to any other. On a basis of seed rate per acre 16 ounce setts at four-foot spacing gave the gross yield per acre. Irrespective of sett weight the optimum spacing was four foot on three foot ridges. Because of the irregular germination particularly amongst the smaller sett weights, a modified experiment based on the above is being repeated this year.

The design of the experiment for Water Yam (*D. alata*) was similar to the above but there was only sufficient material to plant 4, 10 and 16 ounce setts at the four spacing intervals. The higher sett weight gave superior germination and also gave higher nett and gross yields at closer spacing than other treatments.

The high yield at closer spacing is got at the expense of high seed rate and high population plant density. Therefore, in *D. alata* the best spacing using a standard seed rate of 1.5 tons per acre, that is about 16 ounce setts, would be either three or four foot spacing on three-foot ridges and this would give a gross yield of from eight to nine tons per acre.

Relative growth rate experiment.—In earlier experiments (1957 and 1958) a study of the relative growth rates were made using the mean fresh weights of tubers and vines. A further experiment was carried out using white, yellow and water yams. Ten samples were taken at fortnightly intervals, the vines and tubers were weighed and the dry matter content of the tubers determined. The object of the experiment was to determine the change in dry matter content during the growing season and to serve as a guide for future studies on nutritional experiments.

The results from this experiment confirm those previously carried out. The most important result from the experiment is that rainfall during the first four months of growth should not be less than 35 inches. It is desirable to have the highest monthly rainfall in June when most of the setts have germinated. From the fifth month after planting there is a steady decline in the fresh vine weight with a concomitant increase in the fresh and dry weights of the tubers. A correlation is suggested between rainfall, vine weight and tuber weight in the three species examined. In summary, irrespective of the species, a total rainfall greater than 35 inches during the first four months of growth ensures optimum growing conditions for the young vine and therefore a high vine weight with a subsequent high tuber yield.

Storage trial.—Yam tubers are difficult to store. Under the normal storage conditions a loss in a period of six months, of up to forty per cent of the total weight yam result. This loss is due to fungous diseases and to loss of moisture. A small experiment was attempted to determine whether this loss in weight was due entirely to the evaporation of water from the tuber.

Tubers from three clones from each of the three species of yams, namely white, yellow and water yam were stored under normal storage conditions in the yam barn. At fourteen day intervals the tubers were weighed and samples taken for dry matter determination. The storage period was 100 days.

The tubers from the three species all showed a loss in weight. The tubers of white yam showed the greatest loss of 30 per cent of their initial weight, yellow yam about 25 per cent and water yam only about 10 per cent. The apparent gain in dry matter was only five, four and three per cent respectively. It would appear that weight loss is not due entirely to loss of moisture content but to respiration of the tubers. The loss in weight by moisture content is probably a result of the tuber coming into equilibrium with the environmental humidity.

It will therefore be necessary for further investigation into the conditions affecting the rate of respiration and experiments using various chemical compounds to reduce the respiration rate of stored tubers.

Sweet potatoes

Plant Breeding.—Several hundred pollinations were performed with three main objectives:

I Self and cross-pollinations of all parent stocks to study self sterility and cross-incompatibility. Unfortunately there were insufficient flowers to confirm results from earlier experiments.

II Crosses and their reciprocals between five high yielding varieties.

III Crosses and their reciprocals between three high yielding varieties and selected varieties with desirable characters such as flesh colour, shape of tuber, and resistance to virus diseases.

As well as the above all open-cross seeds were collected. The seeds collected have been germinated and are being transplanted into the field for multiplications. They will be scored for virus resistance and favourable agronomic characteristics.

Variety trials.—Seven parent varieties and two selections from the 1958 hybridisation programme were tested in a randomised block experiment. Four varieties Lagos White, B5, Large Leaves and 0116 gave yields greater than four tons per acre ($P=.01$). These varieties did not show field symptoms of virus diseases.

Progeny trial.—Thirty progeny from the 1959 pollination series were tested against two parent varieties. None of the progeny outyielded the parents. Sixteen of the progeny have been retained for further trial.

Variety trial—Vom.—Five stock varieties and one hybrid selection were placed in trial at the Federal Veterinary Research Station, Vom, with the object of determining the best yielding variety for that station.

The establishment of the cuttings was poor but the yield from the remaining stands was very good. Two varieties were noted as suitable for the production of dry season fodder. In conclusion, it would appear that if adequate management is given at the time of establishing the cuttings then sweet potatoes can be grown for cattle feed at Vom.

Time of planting and harvesting.—At Moor Plantation during November and December sweet potatoes suffer from severe infestation from the sweet potato weevil (*Cylas puncticolis*). It was found from results of earlier experiments that harvesting in October resulted in a higher percentage of insect free tubers. In the present experiment planting was carried out in April and in May, the later being the normal planting date for the Ibadan area. Harvesting was carried out at 140, 160 and 180 days from planting.

Harvesting 180 days after planting gave much higher yield of tubers than those harvested at 140 and 160 days irrespective of the date planted. There was no significant difference in yield between April and May planting but there was much less attack by the weevil on the earlier planted plots. The tubers from the April planted plots were small and of better shape than tubers from other plots.

Time of harvesting and spacing trial.—In this trial the effect of time of harvesting and spacing distance was studied. The cuttings were planted at 8, 12 and 18 inches apart on three-foot ridges and harvesting of the plots was carried out at 140, 160 and 180 days from planting. The trial was planted in May.

The optimum spacing and time of harvesting was found to be 12 inches and 180 days respectively giving a yield of more than six tons per acre.

Cocoyams

The material in the collection was planted for multiplication for trial next year. Unfortunately the site used was unsatisfactory and much of the material died.

Cassava (Th. van der Feijst)

The collection and classification of Nigerian cassava varieties was continued. One hundred selected clones from the 1956 and 1957 series of pollinations were added to the collection for variety yield trials or breeding work.

Regional trials.—A new series of variety yield trials of one year duration has been planted in the Regions to compare the yields of the varieties selected at Moor Plantation and Mokwa with the yield of the highest yielding or most widely grown local variety at each centre with the object to select the highest yielding variety for each centre. The trials were planted at the following sites: Agege Experimental Farm, Ilorin Farm Centre, Mokwa Research Station, Akure School Farm, Osara Farm Centre, Yandev Research Station and Ilora Crop Research Station. Only four varieties, 58382, 53101, 57174 and 57171 could be planted at all the centres due to a shortage of planting materials. The design of all trials except the one at Ilora is an eight variety Latin Square. At Ilora eight varieties were planted in a randomised block with six replications.

The germination of the varieties in the trials at Mokwa, Akure, Osara, Yandev and Ilora was rather poor due to the use of partly dried out planting materials. At Mokwa the germination was poorest for variety 59394 (45.4 per cent); at Akure, Osara and Yandev the germination was poorest for variety 57171 (respectively 25.3, 44.6 and 20.4 per cent) while at Ilora the germination percentage of variety 57174 was only 30.0. The germination at Agege and Ilorin ranged between 81.7—93.9 per cent and between 72.9—94.2 per cent of the number of cuttings planted. The trial could not be supplied.

The Western Region Ministry of Agriculture and Natural Resources was provided with planting materials of selected high yielding varieties for the planting of a variety trial at Auchi and Agbor. The design of these trials is a six varieties randomised block with six replications.

The variety trial of eleven varieties, which, was planted at Effurun in 1959 to compare the yields of new hybrids from the 1955 series of pollinations with the yield of the local variety (57176) and other varieties collected from areas of high rainfall in Nigeria, was harvested after thirteen months and one week growth. The yields were very low which was thought to be due to waterlogging. As in 1958 and 1959, variety 57176 was the highest yielding variety. The local variety gave a yield of 2.4 lbs per stand, equivalent to 3.9 tons per acre which was a significantly higher yield than that of any other variety in the trial.

To determine the optimum plot size and shape for cassava trials in the Southern Guinea Zone a uniformity trial, using variety 43083 has been planted at Mokwa.

Agronomy trials.—Investigations into the effect of type of planting materials on the yield of cassava were continued. From two low-branched varieties, 53101 and 43083 cuttings were planted from the base of the main stem, from the base of the primary branches and from the base of the secondary branches while from two high-branched varieties, 32031 and 44086 cuttings were planted from the base of the main stem, from the top of the main stem and from the base of the primary branches in a split-plot experiment with four replications.

The effect of the method of planting on the yield of cassava is being investigated in a three varieties split-plot experiment with four replications. The varieties used are 53101, 43083 and 58389 and the treatments are flat, sloping and vertical planting. There was a significant difference in germination between treatments at one month but not at six months after planting. Cuttings which were planted vertically germinated significantly earlier than sloping of flat planted cuttings ($P=0.001$) while sloping planted cuttings germinated significantly earlier than flat planted cuttings ($P=0.01$).

Breeding Programme.—In the 1958-59, 1959-60 and 1960-61 series of pollinations, *M. utilissima* x *M. glaziovii* interspecies hybrids selected for mosaic resistance were selfed, crossed with cassava varieties showing mild and severe symptoms of mosaic disease and intercrossed. The pollinations were made in order to examine the segregation of mosaic resistant individuals in the progeny and to combine together the mosaic resistance of the interspecies hybrids with the high potential yield of the *M. utilissima* interspecies hybrids. Moreover, in the 1958-59 series of pollinations, *M. utilissima* x *M. melanobasis* interspecies hybrids were produced to investigate the inheritance of the reported high protein content of *M. melanobasis* and in the 1960-61 series of pollinations the mechanism of the inheritance of male sterility, as shown by variety 60452 is being investigated by backcrossing 60452 (a selfing of 53101) to 53101, a fully male and female fertile variety.

Four hundred and eight seedlings of eighteen different selfings and crossings from the 1958-59 series of pollinations were harvested from the nursery and planted in their first stage of multiplication at Moor Plantation with plots of 53101 planted as a control at regular intervals. Twenty-five clones gave enough planting materials to plant them in a randomised block yield trial with four replications and five plant plots.

A total of thirteen hundred and seventy-four seedlings of thirty-four different selfings and crossings from the 1959-60 series of pollinations were planted in the nursery at Moor Plantation during the year.

A total of three thousand six hundred and thirty-three germinated seeds of thirty different selfings and crossings from the 1960-61 series of pollinations were planted in soil blocks in the greenhouse at Moor Plantation at the end of the year.

Cassava mosaic.—The effect of primary infection of cassava with mosaic disease on the yield of cassava is further tested in experiments at the Northern Region Research Stations, Samaru and Mokwa. Randomised plots were planted with cuttings from symptomless stocks and with cuttings from infected stocks (primary infection) of the varieties Zuru local, Gama Gari, Samaru Dan Warri, Zonkwa Dan Warri and Doneji at Samaru and variety 43083 at Mokwa.

The plants grown from cuttings from symptomless stocks at Samaru were, at three months after planting, almost all free from infection with mosaic disease while the plants grown from cuttings from infected stocks of all varieties except Zuru local were all infected. At Mokwa there was no marked difference in percentage infection with mosaic disease between the two treatments. Both plants grown from cuttings from symptomless stocks and from infected stocks were almost all infected by mosaic disease.

The effect of the primary infection with mosaic disease on the yield of the varieties in the two trials will be published in a later report.

Maize

Review of Research on Maize in Nigeria.—A review of extant data on maize in Nigeria was begun. In the first instance a review was made of records prior to 1950. The early records on maize go back to the mid nineteenth century. Frequent records are available from the end of that century onwards.

Most early experiments were concerned with the use of covercrops and their management. Their influence on soil fertility was often tested with subsequent maize crops. Other trials dealt with fertilizers, spacings and time of planting of maize. Several variety tests were carried out. A more or less continuous record is now available on the Moor Plantation variety of maize, Lagos White.

A considerable external trade existed in the early years of the 20th century, which declined during the first world war and never recovered, although on several occasions the floury white grains, typical of Southern maizes, were judged to be of a high marketing value.

Former yield trials.—During 1958 yield trials were carried out at nine locations in Nigeria. A co-analysis was carried out on those trials and the figures obtained in 1957. No significant correlations were found. However, most correlations for results at any one location during the two years were positive or had a very low negative value.

The varieties Mexico 1 and Mexico 5 behaved very differently in 1958 than in 1957. Mexico 1 was the highest yielder in several rain forest trials, although it had continuously been the lowest yielder in the 1957 trials. Mexico 5 gave opposite results. The variety Trinidad maintained its high yield level.

Synthetic varieties.—Two synthetic varieties have been produced by combination of inbred lines selected for high general combining ability. The synthetic ES.1 is based on selections from the variety Trinidad and has yellow flinty grains and the synthetic ES.2 has been selected from Mexico 5 and has white dent grains. The synthetic variety ES.1 has given an increase in yield of an average of 13 per cent, in the trials of 1960, apart from those in the wetter areas of the Eastern Nigeria. ES.2 has not given such results. Both synthetics are to undergo further tests in 1961.

Early and late testing for combining ability of inbreds.—The performance in yield trials of S1—and S4—top crosses of inbred lines of maize derived from the variety Mexico 5 were compared. The better combining S1—lines did not necessarily give rise to good combining S4—lines. Comparisons of S4—top crosses originating from a same S1—line showed that remarkable differences (up to six times the standard error of a mean) existed between those derivatives. It is suggested that an early test for combining ability is not the best procedure to derive desirable and good combining inbred lines, at least in the variety Mexico 5.

Combining ability of open pollinated maize varieties.—A number of white grained varieties have been tested in former years on their yielding performance. Seven of these, Lagos White, Eafro 231, Mexico 1, Mexico 5, Mexico 13, and Sicaragua have, at one time or the other given such promising results as to deserve further attention. These varieties were crossed with each other in all possible combinations and grown in yield trials. Most varietal crosses gave yields from 30 to 50 per cent more than the average of the parent varieties. The results up-to-date are too few to indicate particularly and consistently promising combinations and the programme has to be continued. It is noticeable however that the local variety Lagos White and the variety Sicaragua have been giving the best combinations on the average. Eafro 231 took the third place.

Dwarf varieties.—Five dwarf varieties were introduced from the United States of America. Three of the varieties were extremely susceptible to leaf blights, especially *Cochliobolus heterostrophus.* Three of the lines gave a very low pollen production and could not be maintained. The others were partly inbred and partly crossed with the variety ES.2 in order to introduce the "short node" character into a high yielding, but too tall variety.

Development of a local and an introduced variety of maize.—Growth data (leaf areas, weights of various plant parts, etc.) have been collected at weekly intervals from plant populations of the local variety Lagos White and the introduced variety Mexico 5 to investigate any differences in development. The data have been compiled and are to be analysed.

An interesting feature emerged from the internode measurements, taken at tasselling time. The height of the Lagos White plants was slightly less than that of the Mexico 5 plants and the number of internodes was one less for the Lagos White plants (average 17.5 internodes). The internode patterns (lengths of the internode set off against its serial number when counted from the base upwards) were almost identical for the two varieties.

Rust.—Although the importance of the American maize rust has greatly declined for the present time, the selection for more resistant inbred lines of maize is being pursued. The main source variety is Mexico 13. A number of inbred lines had been selected in former years for a low rust reaction. During the inbreeding process they had lost vigour and only very poor growing inbred lines

resulted. The most promising inbred lines with a low rust reaction were bulked, grown in isolation and allowed to inter-pollinate. The plants of the population so produced had a very low occurrence of rust and is backcrossed with the synthetic variety ES.2 and with Lagos White. Inbred lines are to be established from those three sources to obtain vigorous inbred lines with dent seeds or with floury seeds.

Another source of rust resistant material has been found in Tanag II, selected by the East African Agriculture and Forestry Research Organisation. It shows a rather high degree of resistance and is being used similarly to Mexico 13 as a source for inbred lines carrying rust resistance combined with various white grain types.

Selection of seedlings for rust resistance.—In an attempt to secure vigorous, advanced inbred lines with a homogene rust resistant reaction, plants are grown in the greenhouse and infected artificially with a spore suspension. In order to improve the results of the inoculation, comparisons were made between various methods of inoculation:—

1. the usual method of removing the bloom from the leaf by rubbing it between the fingers and placing a spore suspension in distilled water on the leaf.

2. No removal of bloom and the spore suspension mixed with 0.1 per cent agar.

3. No removal of bloom and the spore suspension mixed with 1 cc teepol per litre.

The second method gives a profuse growth of uredosori and is now replacing the old method of removing the bloom and using only distilled water for the spore suspension, for multiplication of rust in the green house.

Inoculation of inbred lines is now being done with the aid of a hypodermic needle with which the spore suspension (in distilled water) is brought into the funnel of an eight-day seedling. No incubation is then necessary and the risk of the development of various leaf blights is reduced.

It was found that with the original method of inoculation an earlier inoculation than on the tenth day was not advantageous for the growth of the seedlings and that rust symptoms tended to become masked by dying back of the cotyledon and first true leaf with earlier inoculation.

Seedlings of inbred lines were found to be remarkably more vigorous in a compost prepared locally from vegetative refuse, than on the artificially composed mixtures of sand, saw dust and fertilizer in current use at present.

Selection for resistance against Cochliobolus heterostrophus.—The 182 inbred lines developed from selected West African varieties of maize during the first season were grown and submitted to a weekly inoculation with *Cochliobolus* spores from the 18th day after planting. A suspension of macerated cultures was brought into the leaf whorl. Lesions produced were assessed seven days later on the newly emerged leaves. The most resistant plants were inbred to produce second stage inbred lines.

The quantitative reactions of 650 local maize varieties, as observed in 1959, were set out on a map of Nigeria. The varieties with a lower score occur in the forest zone except for a triangular wedge with susceptible varieties just East of the river Niger. Trade and accidental movements of maize grains could be responsible for the phenomenon of leaf blight susceptible maize varieties in a zone where natural selection would have eliminated those and actually did to the west, south and south-east of the area. It is known that a trade of maize occurs in this area from north to south, for example from Idoma and Igala divisions towards Onitsha.

Inoculation experiments with Cochliobolus heterostrophus.—A start has been made with a study of the reaction of maize plants to *Cochliobolus heterostrophus,* a serious leaf blight on maize. Preliminary inoculation experiments on parts of maize leaves kept in petri dishes lined with moist filter-paper at a temperature of 30°C, proved that within 24 hours symptoms developed, whereas leaves kept at 22°C developed symptoms only within 48 hours. The rapid deterioration of these leaves made an accurate assessment impossible. Symptoms developing on the very susceptible variety Mexico 1 and the more resistant ES.2 gave no consistent differences.

Inoculation experiments in the green house gave more promising results. Seedlings of various ages (12, 22, 29 and 33 days) of the above mentioned two varieties were sprayed with a suspension of *Cochliobolus* spores. The seedlings were kept in a humid chamber for 48 hours. The first symptoms developed after 48 hours. Measurements of the lesions indicate that the sizes of the lesions diminish with increasing age of the seedling. The lesions on the susceptible variety Mexico 1 were higher than on ES.2. The results are still under analysis.

Economic importance of Cochliobolus heterostrophus.—The two varieties Mexico 1 (very susceptible to *C. heterostrophus*) and ES.2 were planted in a replicated field trial and sprayed with various concentrations of the fungicide "Cuman" at weekly intervals. The results of this trial show a considerably higher yield for the plots treated with the highest concentration of the fungicide, approximately 15 per cent more than the control plots. The variation within the trial was too high for the differences to be significant and the trial is being repeated.

Legume Investigations (Dr G. P. Tewari)

Cowpea (*Virus sinensis L.*) *Agronomy.*—In field experiments, it is important to reduce variation between plots in a block. In order to test the effects of soil heterogeneity and determine the macro and micro plot size a uniformity trial was set up at the Ilora Crops Research Station. Later in the season a very heavy insect infestation prevented flower formation to such an extent that the experiment had to be discarded.

An experiment was laid down at Moor Plantation, to study the effect of different spacings on planting cowpeas. It was a simple randomised block design with three spacing treatments (eight inches, twelve inches and sixteen inches) on ridges, three feet apart. Each treatment was replicated eight times. In some blocks the effects of soil heterogeneity on some treatments were so strong that the blocks showing these effects had to be discarded.

Later some wilted plants were observed in the plots. On examination, the roots of these plants were found to atrophy in the root tissues. These larvae were sent to the Federal Entomologist whose reports indicated that they belonged to a beetle of family *Euprestidae*. This particular type of insect damage to

cowpeas was not mentioned in literature. A picture of the infested cowpea roots was taken in the Federal Photographic laboratory. On further examination of the atrophied roots, disintegrated parts of shiny shell and a pupae were found and sent to the Federal Entomologist. It is very hard at present to assess economically the extent of damage caused by this insect to the cowpea production in this country. It would largely depend upon how widespread this damage is. The planting of the trial was followed by a long dry spell. The data has been collected and analyzed. Yields of dry pods and dry bean per acre both at 15 per cent moisture basis were recorded. The main reason for recording the yield in this fashion was to see if there was any correlation between these two varieties. Based upon the analysis of variance there was no significant difference between different spacing treatments. However, in view of the insect damage and the adverse environmental condition, not much reliance should be placed upon this result. The analysis of co-variance to measure the co-efficient of correlation between dry pods per acre and dry shelled beans per acre did not show any significant correlation. However, two important points have emerged from this study, one is that samples taken from the same bulk sample vary widely in their moisture content and hence, it would be advisable to determine the moisture percentage of each plot yield at the time of recording the weight and second is that it would be better to record the yield in terms of dry beans per acre.

Storage trial.—In the absence of proper storage facilities it is extremely important to find a suitable method of storing cowpeas and other grain legume seeds to maintain their viability over a long period of time. Sometimes much time and effort is wasted in growing cowpea varieties from year to year just to maintain a viable seed stock. It has been reported that temperature and moisture are some of the most important factors influencing the seed viability. A laboratory experiment was designed to evaluate the effects of storage of cowpea seeds under refrigeration, at room temperature, and in air-conditioning, on seeds in paper packages, sealed polythene bags, glass jars and desiccators. Treatments under each of the three temperatures were replicated three times. Ten seeds from each treatment at a fixed interval, were tested for germination percentage. The test has been concluded and data analyzed. No significant difference, either between the different containers or the temperatures, was observed. It is important to mention that due to lack of proper facilities for this kind of work, ideal conditions could not be obtained. For valid assumptions it would be necessary to repeat the test under proper experimental environment. It is generally recognized that the weevil infestation presents a serious problem in storing cowpea seeds. It has been suggested by Roberts (Annals of Botany, 1960, pp. 28) that "the most convenient method would be to dry the seeds to low moisture content and place in air-tight containers; if necessary, the viability could be increased still further by placing the containers in a refrigerator". In this regard it would be wise to store, if possible, only the healthy seeds, free from the mechanical and the biological injury. Glass jars with tight fitting caps could be useful containers for this purpose.

Planting dates study.—As mentioned in an earlier report this study was planned to measure the photoperiodic response of three cowpea varieties with special reference to the flowering time and yields. This was a split plot experiment. Six planting dates, namely 14th April, 14th May, 14th June, 14th July, 14th August and 14th September were the main plots. Sub-plots consisted of three cowpea varieties (Paraguay 6, 6347, V-36-1 and 6460, V106-10). Treatments were replicated twice. The experiment was recently concluded and the data analysed. Results showed that the varietal difference in regard to the times of initial flower appearance reached a five per cent significant level. Variety 6247,

V-36-1 was the earliest flower forming, Paraguay 6, the next and variety 6460, V-106-10, the latest among the group. Earliest one took 43 days to initiate flower formation while the latest one took 49 days. The trend was similar in regard to the days when the maximum number of plants of any single variety were in flower. Again variety 6460, V-106-10 was the latest. It took on an average (for all dates) about 67 days before the majority of the plants of this variety reached the flowering stage.

The analysis of variance showed that there was significant difference between different planting dates, between varieties and also an interaction between varieties and planting times. Dates reached a five per cent level of significance while varieties and varieties x dates each produced difference at one per cent level of significance. On an average for all varieties the April planting produced the maximum number of flowers within 54 days while the August planting took 67 days, thirteen days more. Except for the variety, 6460, V-106-10, the majority of the plants of the other two varieties from April planting took the least number of days in reaching the complete flowering stage. August planting of all three varieties took the greatest number of days before 75 per cent of the plants reached the flowering stage. Variety 6460, V-106-10 differed from these two varieties and 75 per cent of the stands took the least number of days to reach the flowering stage when planted in September. These results indicated that Paraguay 6 and 6247, V-36-1 are the early maturing and variety 6460-V-106-10 a late maturing in comparison among these three varieties.

Yields from this experiment were analysed by the analysis of variance method. 'F' value for planting dates and varieties reached a five per cent level of significance while the interaction between planting dates and varieties was significant at one per cent level. For all varieties combined together, the June planting gave the highest yield while the July planting gave the lowest. Variety 6247, V-36-1 was the highest yielding variety and variety 6460, V-106-10 the lowest in rank. Paraguay 6 when planted in April gave the highest yields but varieties 6247-V-36-1 and 6460-V-106-10 produced the largest amount of grains when planted in June. Except for the last one, the other two varieties yielded almost nothing from their September planting. A general attitude has been to recommend the late planting of cowpeas but the result of the experiment with two indigenous and one introduced varieties have clearly shown that June planting was the best from yield point of view. This finding, if further substantiated may benefit the farmers economically. A detailed account of this experiment will be published elsewhere.

N-P-K Fertilizer experiment on Cowpea at Agege.—A factorial (3×3) N-P-K fertilizer experiment was conducted at the Agege Regional Crop Research Station. Three major elements, N, P, and K on the basis of N_2, P_2O_5 and K_2O at the rate of O, 20 and 40 pounds per acre were applied. There were 27 treatments in all and each treatment was replicated three times. Each replicate had three blocks and each block contained 9 plots. The plot size was 180 square feet. Data has been collected and partially analysed. Yields were correlated to stand at one per cent level and hence the yields figures were adjusted. Analysis showed that the 'N' effect was significant at five per cent level of significance while the effects of 'P' and 'K' were significant at one per cent level of significance. The first order interactions namely the NP, NK and PK were also significant at one per cent level. Application of 20 pounds of P_2O_5 per acre gave the highest yield response. Net highest response was obtained by the treatment K_1 (20 pounds of K_2O per acre). It is interesting to note that N_1, P_1, and K_1 each applied at 20 pounds per acre gave much higher yield than at any other rates. Higher rates of application actually depressed the yields. N_0P_1 (20 pounds of P_2O_5 per acre and no nitrogen) gave higher yield than any other combination of these two compounds. N_2 P_2

gave a slightly higher yield but neither statistically significant nor economically profitable. The response of potassium was identical. N_0K_1 (20 pounds of K_2O per acre and no nitrogen) gave the highest yield and proved to be the best of all the combinations of these two. As pointed out earlier the interaction PK, was statistically significant. Comparing all the different combinations of phosphorus and potassium, P_1K_1 (20 pounds of each per acre when applied together) gave the best yield response.

Results indicated that 20 pounds per acre of N_2, P_2O_5 and K_2O could be economically most profitable under the present conditions. Full details of this experiment would be published somewhere else.

Inoculation and spacing trial at Moor Plantation.—A split plot experiment on Paragraph 6, variety of cowpea was conducted at Moor Plantation to measure the effects of seed inoculation (commercial Rhizobium inoculant) and six different spacings. Main plots consisted of inoculated and uninoculated seeds and each main plot had sub-plots of six different spacings, namely, 8″, 16″, 24″, 32″, 40″ and 48″. Treatments were replicated three times.

Inoculation did not produce any significant difference in yields. Spacing treatments were significant at five per cent level and a further analysis according to multiple range tests showed that only 16″ spacing yielded significantly higher than the 48″ spacing. Otherwise no significant difference was noted between other spacings treatments. An average yield from sixteen inches spacing was 1,073.16 pounds of cowpea grains (at 15 per cent moisture) per acre. The lowest yield (648.23 pounds per acre) was from 48″ spacing treatment. In this experiment 16″ spacing seemed to be the optimum spacing.

Observation studies on cowpea.—About 500 different lines of cowpea were tested at Field A1 on Moor Plantation. Observations were made in regard to the date of flower initiation, average yield calculated on the basis of single plant, flower colour, vigour of the plant, growth habit and other characteristics. Collections from Samaru were tested also for resistance to cowpea virus. Data collected from these tests are being tabulated. This information would be very valuable at the present and also in the future legumes programme. At the present time there is very little information available on agronomic characteristics of these lines. Some varieties have a capacity for higher yield but are susceptible to virus and other diseases. After a comprehensive screening of these lines it may be possible to locate resistance in relation to specific disease problems. It is encouraging to note that several lines which have proved to be higher yielder, have also shown a high resistance to mosaic virus. In these observation trials and also in other experiments, stem rot has been found to be a very serious disease under Moor Plantation condition. It would be necessary to locate resistance to this disease. It would also be necessary to visit farmers' plots and assess the extent of the damage caused by the stem rot.

Miscellaneous Legumes

Soya bean (*Glycine max.*).—Three different varieties of soya bean were imported from the United States Department of Agriculture. These were tested in observation plots on Moor Plantation. Two of these introductions performed very well. It is hoped to test these two varieties in comparison to the Malayan variety commonly grown in Northern Nigeria.

Pigeon Peas (*Cajanus cajan*).—A few high yielding varieties of pigeon peas were imported from India and these are being tested at Moor Plantation.

Other Legumes.—Several other legumes and several varieties of each *Canavalia ensiformis, Cicer arietinum, Cyamopsis tetragonolobus, Dolichus lablab, Styzolobium deeringianum, Voandezia subterranea* were imported from U.S.D.A. It is hoped to maintain this stock for future use.

Tree Crops

Kola (Th. van der Feijst).—Individual tree yield recording was continued at Moor Plantation and at Agege. Thirty-three per cent of the trees in plot KD, KE and KW at Moor Plantation produced a crop, the mean yield per bearing tree being 101 seeds. The most outstanding tree (KD6) produced 2,711 seeds, a yield of 68 lbs.

Forty-eight per cent of the trees in plot AA, AB, AC, AD and AF at Agege produced a crop during the 1960-61 season. The mean yield per bearing trees was 365 seeds. The most outstanding tree (AA86), one of the trees which were selected in 1960 for their high yield during the period 1952-60, produced 2.827 seeds, a yield of 110 lbs. When the mean yields per bearing in 1960-61 were compared, it was found that trees planted in 1917, the oldest under observation gave a yield of 460 seeds which was higher than that of trees planted between 1925 and 1935. Twenty-one per cent of the trees in plot AE which were planted in 1950 produced a crop, the mean yield per bearing tree being 54 seeds.

It was impossible to continue the investigation into the inheritance of cotyledon colour as only 128 flowers could be artificially pollinated at Moor Plantation due to sparse flowering; of the pollinated flowers only 10 set fruit.

The 66 trees *Cola acuminata* (ex Iware, Ilesha and Ogbomosho) which were planted at Moor Plantation in 1949 have not yet given any yield, although they have been flowering for some years. In order to investigate if this is due to the lack of active pollinating agents two flowers were selfed. Both artificially pollinated flowers set fruit. The pods were rough and wrinkled and the seeds had only two cotyledons which suggest that these trees belong to the species *nitida* and are not *C. acuminata* as was originally stated. Artificial pollinations on these trees will be continued.

For the planting of proposed progeny trials at Moor Plantation, Agege and Akure in 1962 an extensive programme of pollinations has begun at Moor Plantation, Ina Farm and Agege. Selected high yielding trees grown from white seeds at Moor Plantation were selfed, crossed and cross pollinated with selected high yielding trees from the isolated plot at Ina Farm. At the same time selected high yielding trees grown from pink seeds were selfed and crossed with selected high yielding trees grown from red seeds. At Ina Farm selected high yielding trees grown from white seeds were selfed and at Agege selected high yielding trees grown from red seeds were selfed and crossed.

The results so far have been disappointing due to sparse flowering and poor fruit set. At Moor Plantation 1,586 flowers were pollinated but only 461 flowers set fruit. This resulted in 809 good seeds which were planted in the nursery at Moor Plantation. At Ina Farm 336 flowers were self pollinated but none set fruit. Eight hundred and thirty-nine open pollinated seeds were collected from the selected trees and planted in the nursery. At Agege 368 flowers were artificially pollinated but none of the 348 self pollinated flowers set fruit. This

confirms previous experience that homozygous red seeded trees are likely to be self incompatible. Seven of the cross pollinations were successful and produced 180 good red seeds which were planted at Moor Plantation.

Two hundred seeds of *C. acuminata* which were bought on the Ibadan market and which undoubtedly had been stored for some time germinated remarkably well and much quicker in the nursery at Moor Plantation than seeds of *C. nitida* which were newly harvested. Five months after planting, 57 per cent of the seeds of *C. acuminata* had germinated but only 30 per cent of 347 seeds of *C. nitida.* The effect of storage on the germination of kola seeds will be further investigated.

Experiments have been started to determine the optimum conditions for the rooting of kola cuttings. Different types of rooting media and a wide range of plant hormones are being investigated.

In 1952 an experiment was started in plot AA at Agege to determine the effect on yield of the farmers' method of wounding the trunk of the tree. One hundred and thirty trees were selected for the experiment, of which 40 trees were wounded and 90 trees remained untreated as controls. The mean annual yield for 1952 to 1960 per bearing tree for both treated and untreated trees have been compared. They have also been compared with the mean annual yield of the bearing tree in the plot. However, the differences in yield were not big enough to be statistically significant.

Citrus (Dr J. M. Waterston)

Citrus root-stock trials at Ibadan.—In the acid lime root-stock trial established in 1955 as an index for the presence of *tristeza* virus disease, Sampson Tangelo and Cleopatra Mandarin continued to show superiority as healthy stocks. Sour orange ex Trinidad proved the most susceptible stock, all scions showing characteristic symptoms of *tristeza.* The seedling controls have not exhibited the rapid die-back symptoms recorded at Asuansi, in Ghana, which suggests that the Nigerian strain is a milder one.

Cleopatra Mandarin and Lake Tangelo continued to demonstrate their superiority as stocks for sweet orange in the trial which is now nine years old. Growth on sour orange ceased after four years from establishment and there have been many deaths from *tristeza* on this stock.

FEDERAL RICE RESEARCH STATION, BADEGGI

Mr J. E. Y. Hardcastle, Principal Research Officer, proceeded on vacation leave in May 1960 ; in his absence Mr J. A. F. M. Sluyters, Specialist Officer, and Dr F. C. Bent, Specialist Officer, acted as Officer-in-charge. Mr Hardcastle resumed duty in October 1960 and was transferred to Ibadan in February 1961. The position of Officer-in-Charge was taken over by Mr B. D. A. Beck, Senior Specialist Officer who was posted to Badeggi in January 1961. Mr Th. J. Bredero was posted to the Station as Agronomist in April 1960. Mr F. O. C. Ezedinma, Acting Technical Officer was posted to the Station in April 1960 ; he returned in October 1960. Mr Sluyters proceeded on vacation leave in August 1960 and resumed duty in January 1961. Dr Bent proceeded on leave pending retirement in March 1961. Mr W. A. Porter was posted to Badeggi as Station

Manager in March 1960. He returned to Ibadan in April 1960 and was relieved by Mr S. A. Soremi. Mr Soremi was relieved by Mr S. A. Amudipe, Mechanical Demonstrator, who acted in the post of Station Manager on his transfer from the Southern Cameroons in September 1960. Mr Amudipe transferred to the Western Region Public Service in March 1961 when he was relieved by Mr T. Agulana, Acting Station Manager.

Touring 1960-61

Dr Bent toured the Upland Rice trials in the Western Region in June and July 1960. Mr Bredero toured the deep flooding fadamas in Birnin Kebbi, the Yao Irrigation Scheme, Maiduguri and Shendam in August and December 1960 and visited Samaru and Katsina in June 1960. Mr Hardcastle attended the Eastern Region Cropping Scheme in December 1960. Mr Beck, Mr Sluyters and Mr Bredero attended the Riveraine and Northern Cropping Schemes at Samaru in February and March 1961.

Meteorology

Rainfall at Badeggi in March and April was well above the average, which resulted in a total annual rainfall nearly 6″ higher than the average of 48.76. Rainfall was well distributed and this in combination with the high rainfall in March and April provided ample water for the experimental area and local farmers. The general high yield levels in 1960 might be attributed to the favourable distribution figures. A summary of the meteorological data recorded at Badeggi is given as an appendix to this report.

Plant Breeding

Four distinct ecological zones are used for the growing of rice in Nigeria, these are naturally inundated Lowlands, the non-inundated irrigable Lowlands, the Rainfed Uplands, and the fresh water mangrove swamps.

It is not possible to obtain a single rice variety with a sufficiently wide range of adaptability to cover all the major zones of rice growing in Nigeria. These zones intergrade with one another and in the marginal areas a variety typical of one zone may have a sufficiently wide range of adaptability to be superior to varieties from the neighbouring zone ; but where the ecological conditions are clearly defined it is unlikely that varieties adapted to one environment can compete successfully in another. For this reason the plant improvement programmes have been divided and related to individual zones. The selection of imported varieties has continued and breeding programmes to combine high yield and grain type with short life period have been commenced among the varieties adapted to the naturally inundated and the non-inundated irrigable lowlands.

The standardisation of laboratory milling tests has been commenced and factors affecting the out turn of whole grain at milling, such as optimum parboiling time, milling pressure and milling time for the different grain types are being examined. The results of this work were not completed at the time of writing and will be published later.

The Naturally Inundated Lowlands

The fadamas of the major river systems in the far North of Nigeria are subject to seasonal deep flooding as the rivers rise ; they are the traditional areas of cultivation of indigenous, red grained varieties of *Oryza glaberrima.* In 1960

those projects aimed at the selection of high yielding, white grained, floating varieties of *O. sativa* with a flood resistance comparable with that of the indigenous floating *O. glaberrima* types were continued.

Intervarietal trials.—The trial to compare the yields of eight floating varieties of *O. sativa* was continued at Badeggi for the third year. In 1960 the depth of water and the rate of flood flow on the trial were not sufficient to give the varieties rigorous test. As in 1958 and 1959 Tisei was the highest yielding variety in trial, giving in 1960 a yield equivalent to 2,970 lbs. of paddy per acre. There was no significant difference between the yields of Tisei and Nan Rung ; Tisei gave a significantly greater yield than any other variety in trial. In a non-parametric analysis of the yields of seven floating varieties over the last three years Tisei was the highest yielding variety ($P=0.01$) and the overall yields obtained in 1960 were greater than in either of the previous years.

The comparison of the yields of thirty-one floating varieties of *O. glaberrima* was continued at Badeggi. Again the varieties were not subjected to the rigorous conditions which obtain in the Northern fadamas and yields were very high. Badande was the highest yielding variety giving a yield equivalent to 3,200 lbs. of paddy per acre. There was no significant difference between the yields of Badande and Jatau, the highest yielding variety in 1959 ($P=0.01$) and five other varieties in trial. In a joint analysis of the 1959 and 1960 trials Badande was the highest yielding variety ($P=0.01$) and the mean yield of varieties in 1960 was significantly greater than in 1959 ($P=0.01$). There was a very highly significant positive correlation between yield and life period of the varieties in this trial ($r=0.548$) and also in the 1959 trial ($r=0.704$).

At Birnin Kebbi, Tisei and Mali Ong gave yields equivalent to 1,091 lbs. and 909 lbs. paddy per acre ; both outyielded the widely grown glaberrima variety Babban Fari. The duration of the flood was too short to enable Nan Rung and Tau Binth to reach maturity. Contamination of the plots with volunteer glaberrimas was very low and did not exceed 3 per cent. The sativa varieties Mali Ong, Indo China 53 and Champa were multiplied at Badeggi in 1960 and have been distributed to farmers at Birnin Kebbi for the 1961 season.

At Maiduguri the observation plots were over grown with volunteer glaberrimas, only Nan Rung shewed any competitive ability and paddy harvested from this plot contained 50 per cent red rice.

Intra species hybridisation and selection

Among the sativa varieties tested for deep flooding conditions only Tisei approaches the indigenous glaberrima lines in vigour and yield. However, Tisei is not suitable for distribution as it has red grain. Nan Rung is potentially high yielding, but the duration of the flood in many areas in the North is not long enough to allow it to mature ; in general the life periods of the sativa introductions are longer than those of the glaberrimas. One of the more recent acquisitions, Indo China Blanc, has a life period of 194 days in the variety collection at Badeggi and this approaches the life period of the glaberrimas ; this variety is being used in a breeding programme to combined earliness with high yield vigour and flood resistance of the other varieties. Four hundred and four selections for earliness have been made within the varieties Mali Ong, Champa and Indo China 53 and these will be tested at Badeggi in 1961. An *O. glaberrima* variety with white grain has been introduced from Senegal and this will be used in a back-crossing programme to introduce a white grain into the varieties Badande and Jatau.

Interspecies hybridisation

The F_2 generation of interspecies hybrids between *O. glaberrima* and *O. sativa* from the 1958 series of crosses was grown at Badeggi and F_3 seed was obtained. The F_1 generation of a further series of crosses, carried out in 1959, was also grown and F_2 seed obtained. This project is aimed at the selection of favourable combinations of characters from both species. Selection on the F_3 generation will commence in 1961.

Non-inundated Irrigable Lowlands.—The progressive screening of promising introductions for the non-inundated irrigable lowlands was continued ; the main emphasis was on the production of a higher yielding replacement for the main crop variety BG 79 and for the deep water varieties Toma 112 and Kav 12.

The breeding programme with the object of producing an early maturing variety with a life period of 3 to 4 months when planted in July suitable for areas of limited rainfall was continued.

Regional yield trials.—The current main crop variety trial including the varieties ADT-20, BG 79 (control), D 52/37, D 114, MAS 2401 and PADI SAWAH III was replicated in the riveraine provinces, Adamawa, Ilorin and Zaria in 1960. Combined analysis with previous trials were carried out for the provinces Adamawa (4 years), Benue (3 years), Ilorin (3 years), Niger (3 years), Plateau (3 years) and Zaria (4 years). The combined analysis in each province was done with the varieties BG 79, D 52/37, D 114 and MAS 2401 only. In Zaria Province BG 79 was outyielded significantly ($P=0.05$) by D 114, D 52/37 and MAS 2401. As a result of this D 114, the highest yielder, has been added to the varieties in the multiplication scheme. MAS 2401 outyielded BG 79 in Niger Province and Ilorin Province ; this confirms the statement in the 1959 Annual Report that on the basis of yield MAS 2401 could be recommended for areas with supplementary irrigation water. There were no significant differences between these varieties in Adamawa Province.

It is not possible to make a general recommendation to replace BG 79 for all the Provinces. Early results from a local miller indicated that D 114 was superior in milling quality to BG 79 and D 53/37, but this has not been supported by subsequent laboratory milling tests. Further experiments on the milling quality of BG 79, D 52/37, D 114 and MAS 2401 are being carried out.

A combined analysis of two palatability tests showed that MAS 2401 was significantly less palatable than BG 79 ($P=0.05$). No significant differences could be demonstrated between BG 79, D 52/37 and D 114.

The variety MAKALIOKA 823, which is 14 days earlier than GB 79 was compared with the standard varieties of five months duration in the Jere Bowl. It produced a yield equivalent to 2,650 lbs. per acre, intermediate between D 52/37, the highest yielding variety which produced 2,710 lbs. and BG 79 which produced 2,460 lbs. The yields of four early varieties (4 months duration) were compared with BG 79 in observation plots planted in Bornu, Bauchi and Katsina Provinces. In Bornu and Katsina CO-9 outyielded BG 79 and in Bauchi BG 79 was outyielded by Tai-Chu 65. Unfortunately CO-9 has a C-type grain and Tai-Chu 65 has a D-type. The observation plots will be repeated in 1961.

Fifteen swamp varieties of *Oryza sativa* were grown at Birnin Kebbi in 1960 under natural shallow flooding conditions. The flood rose slowly to a maximum depth of 5' 2" and none of the varieties was submerged. The varieties of four months duration were

harvested with the flood still on the fields, the five month duration varieties had a receding flood during ripening whereas with the six month varieties the flood had receded one month before harvest. The five month duration varieties were the highest yielding group ; BG79 was the highest yielding variety with a yield equivalent to 3,630 lbs. per acre ; D99 was the lowest yielding of the five month varieties with a yield equivalent to 3,180 lbs. per acre. The yields of the four month varieties ranged from 2,595 lbs. per acre from FA-YIU-TSAI to T6517 which produced 1,305 lbs. per acre. The six months varieties BOLO 108 and TOMA 112 produced a yield equivalent to 2,200 lbs. per acre. Two widely grown local *O. glaberima* varieties were included in this trial, the higher yielding DAN BOTO produced 2,000 lbs. per acre. The trial will be repeated in 1961.

In Plateau Province at Riyom twelve Japonica varieties of O. sativa were compared with BG79. Five of these varieties outyielded BG 79 for the second successive year.

Inter varietal yield trials (*Badeggi*).—The new main crop variety trial with varieties of five months duration was repeated in 1960. MAS 2401 significantly outyielded BG79 (P=0.05) and five other potential replacements (P=0.05-.001). PATNAI and No. 37 outyielded BG79 in 1959 and 1960 although the difference was not large enough to be significant.

The trial of 12 early varieties of 3-4 months duration with BG79 as control was repeated in 1960 and was again planted in early May and the end of October. A combined analysis over 3 years of the early and late sowing each was made. When planted in early May no variety significantly outyielded BG79, but in the October planting BG79 was significantly outyielded by MTU-9, PRECOSE and CO-13 (P=0.05).

In the KAV.12 replacement trial, there was no significant difference between the yields of KAV.12 and PTB-16. In a combined analysis of the 1958 and 1960 results the yields of KAV.12 and PTK-16 did not differ significantly. KAB.12 significantly outyielded all other varieties (P=0.05-0.01), PTB-16 outyielded ANAK DIDEK and KONTOR (P=0.05). The 1959 replicate was not included in the combined analysis as the trial contained 5 incomplete lots but the same trend was evident in the analysis of that year.

In the TOMA 112 replacement trial, which was repeated for the second year, the TOMA reselection did very well and outyielded its parent stock. Siam 29 and two other varieties outyielded TOMA 112 and thus confirmed the 1959 results of this trial. The life period of Siam 29 is about 14 days longer than that of TOMA 112 and is more comparable with that of PTB-16 in the KAV.12 replacement trial.

Intra-species hybridisation.—There is a general demand for a variety of shorter duration than BG79 ; and few of the early maturing varieties introduced from overseas possess the required grain type and yield potential of this variety. In a hybridisation programme aimed at combining the grain type and palatability of BG79 and GEB 24/37 with the early maturity of MTU-9, PRECOSE and Tai-Chu 65 the BG79×early variety crosses in 1960 produced 350 F_1 seed with a mean setting percentage of 51.7 per cent ; crosses based on GEB 24/37 were less fertile and produced 150 F_1 seed with a mean setting percentage of 35.9 per cent. F_2 seed from the 1959 crosses Tai-Chu 65×BG79 and MTU-9×BG79 were harvested.

Mangrove swamps.—The F_2 material derived from crosses between varieties resistant to lodging and varieties possessing a more desirable grain type were sown. Part of the F_3 seed has been sent to the Eastern Regional Research Station for selection in that Region.

Varietal Collection.—During 1960, 108 rice varieties were added to the varietal collection, of which 22 were upland varieties (*O. sativa*), 6 upland varieties (*O. glaberrima*), 75 swamp varieties (*O. sativa*) and 5 floating varieties (*O. sativa*).

The Rainfed Uplands

Regional Trials.—The series of Regional trials to select a higher yielding replacement for the glutinous variety Agbede was continued in 1960.

At seven centres in the Forest Zone of the Western Region two Agbede selections were compared with three other Nigerian upland varieties, an upland variety from the Cameroons and two short duration shallow swamp types. In the 1960 series of trials there were significant differences in the yields of the two Agbede selections ; at Ikole, Agbede 16/56 gave a significantly greater yield than Agbede 140/54, whereas at Igunshin and Erin-Oke Agbede 140/54 significantly outyielded Agbede 16/56. Bikom, the upland variety from the Cameroons was consistently outyielded by the Nigerian varieties in all the trials ; at four centres the yield of Bikom was significantly lower than the Nigeria selections. The two shallow swamp varieties, PRECOSE and MTU-9, failed completely at two sites and their yields were significantly lower than those of the Nigerian selections at the other five centres.

In a non-parametric analysis of this series of trials the highest yielding variety was the Nigerian upland Jete ; this variety produced 2,880 lbs. of paddy at Ijebu-Ode, the highest yield recorded in the upland trials in 1960. There were no significant differences between the overall yields of the upland varieties ; the yields of these varieties were significantly greater than those of the swamp varieties. There were significant differences between the mean yields obtained at the different stations. The highest yields of the upland varieties were obtained at Ijebu-Ode, these varieties gave an average yield of 2,535 lbs. of paddy per acre ; both the swamp varieties failed at Ijebu-Ode.

The shallow swamp varieties were included in these trials because it was thought that as they were of very short duration they would be able to grow in areas of high rainfall on unsupplemented natural precipitation. At Ijebu and Ofada they failed completely, being destroyed in the early stages of growth by the leaf-spot disease-complex of *Piricularia* and *Helminthosporium.* They were heavily attacked by these diseases at the other centres and their extreme susceptibility under upland conditions must account in large measure for their low yields.

This trial was replicated at four centres in the Guinea Savannah Zone in the Northern Region. At Shendam where yields were lower than in 1959, there were no significant differences between the yields of the Nigerian upland varieties. Both the Agbede selections and Oshodi produced significantly higher yields than Bikom and all the upland varieties gave significantly greater yields than the swamp varieties. All the varieties were heavily attacked by the *Piricularia—Helminthosporium* leaf spot diseases, the attack being most severe on the swamp varieties. *Ophiobolus oryzinus* Sacc. was recorded on this trial. At Ajio the

yields were again very low in 1960, Trinidad Hill Rice was the highest yielding variety producing a yield of 470 lbs. per acre ; the yield of this variety did not differ significantly from Jete and BG79. The later variety, a shallow swamp type, was included instead of PRECOSE. In a joint analysis of the Ajio trials over the last three seasons there were no significant differences between variety yields. At Yola the trial was destroyed in the early stages of growth by a severe attack of the leaf-spot diseases and the Badeggi trial failed as it was planted too late in the season.

A new trial to compare four recent upland introductions with the two Agbede selections was conducted at Irrua. The two new introductions from Ceylon, Suduwee and V.I. 28061, were very promising. Suduwee significantly outyielded both Agbede selections, and V.I. 28061 gave a significantly higher yield than Agbede 16/56. Overall yields in this trial were not high, Suduwee produced 1,600 lbs. of paddy per acre, 480 lbs. more than the highest yielding Agbede selection. These varieties will be tested at other centres in the Western Region where higher yields have been obtained from the Nigerian Upland varieties.

It is hoped to commence screening the collection for resistance to *Piricularia oryzae* and *Heliminthosporium oryzae* in 1961.

Agronomy

Time of planting trial.—A trial designed to study the reaction of 8 varieties to changing photo period was planted in 1960 at Badeggi. It included photo-period sensitive and photo-period insensitive varieties with a range of mean tiller number within each group. Plantings were carried out at the beginning of May, July and September. The results were analysed for each sowing and a combined analysis was made for the three sowing dates.

The order of yield of the varieties in the May sowing differed from the other sowings, *e.g.,* BG79 was the highest yielder in the May sowing but ranked sixth and ninth in the July and September sowing respectively. Tjina was the fifth yielder in the first sowing, but was the highest yielder in the 2nd and 3rd sowing. With the other varieties the position did not vary greatly between sowings. The later sowings appeared very variable in the field and it is considered that not too much reliance can be placed on the absolute yield data.

MAS 2401 is more photo period sensitive than was previously thought ; having a life period of 156, 153 and 134 days for the respectively May, July and September sowing. The other varieties had progressively shorter life periods with later sowings except TAI-CHU 65 and PRECOSE which remained fairly constant.

Tiller number, tiller height and panicle weight generally decreased with the later sowings. There was no obvious relationship between the amount of lodging and time of planting. TAI-CHU was the only variety which did not lodge.

Plant population studies.—The results from spacing trials at Badeggi in 1958 and 1959 indicated that a higher yield was obtained from swamp rice when transplanted at $9'' \times 9''$ in the field than when transplanted at $15'' \times 15''$. The increase in yield from the closer spacing more than compensated for yield losses due to a slight increase in lodging. All new trials at Badeggi in 1961 will be planted at $9'' \times 9''$.

The yield response to spacing is, in part, a measure of plant competition in the field. Spacing can conveniently be expressed as the unit area occupied by a single plant and this area may be varied in shape. The yield response to variation in the size and shape of the area occupied by a single plant was studied at Badeggi in 1959 and 1960. Three varieties, which varied markedly in tiller number were compared at three unit areas 36, 64 and 144 sq. ins. per plant. The shape of the unit areas were oblong, with sides in the ratio 1:4, or square with sides in the ratio 2:2. In 1960 there were significant differences in yield between all spacings, maximum yield was obtained at 36 sq. ins. per plant and the minimum yield from 144 sq. ins. per plant. There was no significant difference in yield between equivalent areas of different shape. In a combined analysis of the two years results the yield obtained at 36 sq. ins. unit area was significantly greater than at 64 and 144 sq. ins., but the difference was not large enough to be significant. The shape of the area per plant had no significant effect on yield at 36 sq. ins. spacing. At 64 and 144 sq. ins. per plant, area shape is critical, square areas with sides in the ratio 2:2 gave a significantly greater yield than areas with sides in the ratio of 1:4. There were no significant differences between varieties in this analysis, nor were any of the interactions significant. At 36 sq. ins. per plant the amount of lodging tends to increase and this effect may be worsened under high fertilizer regimes, this will be further studied in 1962.

Nursery Technique.—A trial was started in 1958 and continued in 1960 to determine the optimum combination of cultural techniques in the nursery required to produce maximum yield in the field. Factors tested in all combinations were method of sowing (broadcasting vs. drilling), seedrate (300 lbs./acre vs. 600 lbs./acre), time in the nursery (4 weeks vs. 8 weeks), and manurial treatment (1.3 cwt./acre ammonium sulphate vs. no fertiliser). Seedling were transplanted under uniform cultural conditions in the field.

In 1959 and 1960 there were no significant differences between treatments except for "time in the nursery". Plants grown in the nursery for 8 weeks produced a significantly greater yield than plants grown for 4 weeks. In 1958 however, this effect was reversed, and plants grown for four weeks in the nursery gave a significantly greater yield than plants grown for 8 weeks. This trial will be modified and continued in 1961.

Uniformity trials with swamp rice.—Four uniformity trials were laid down in 1960 as recommended by the results from the 1957 and 1959 trials. A large variability was shown in the 1960 trials mainly due to differences in soil fertility caused by old anthill sites and variation in water level. The results of 1959 and 1960 are being analysed by a method to eliminate fertility differences more completely than the analysis methods that were used previously. The new analysis was not complete at the time of writing and will be published later.

Broadcasting seed rates with swamp rice.—The trial using the variety BG79 to compare four rates of broadcasting of swamp rice was continued for the third year in 1960. There were no significant differences between seed rates of 35, 60, 85 and 110 lbs. per acre. As in 1958, maximum yield was obtained at a seed rate of 85 lbs. per acre ; in 1960 this was equivalent to 2,021 lbs. per acre, 780 lbs. more than from a seed rate of 35 lbs. per acre. The coefficient of variation of this trial was very high, and prevented the demonstration of significant differences between treatments. In a joint analysis of the three years results, although no significant differences were obtained between treatments, there was a clearly

defined trend for yield to increase with seed rate. This will be further investigated in 1962.

Seed dressings on broadcast swamp rice.—The trial to test yield responses to three fungicidal seed dressings showed no significant differences between treatments for the third consecutive year. The order of years viz. Dieldrex, Fernosan D, Fernasan A, control. The results from 1958 and 1959 could not be analysed in combination with the 1960 results, since in the 1960 trial, a higher seed-rate was used. The coefficient or variability was high largely due to inadequate water control.

Herbicide trials on swamp rice.—The effects of different times and rates of application of Dalapon on direct seeded swamp rice were compared in observation plots at Birnin Kebbi. From the results obtained in 1959 and 1960 an application of 10 lbs. of Dalapon per acre once in two years, applied four weeks prior to sowing, is recommended. The value of split applications is doubtful if a second application is given when the ground is flooded.

Fertilizer trials with swamp rice.—All fertilizer trials with variety BG79 are sited on the alluvial soils of the Edozighi Irrigation Scheme and have been run for three or more years. They will be repeated in 1961 for the last time whereafter the residual effect will be studied. Soil, leaf and grain samples will be taken in 1961 from all the treatments and all sited for chemical analysis to compare the uptake of the applied nutrients, especially N, P and K. Experimental control has been good (coeff. var.+10%) and the results will probably form the basis of preliminary fertilizer recommendations for the Kaduna and Niger River flood plains.

EA4(59)R60 has been laid out on three soil series, the Edozighi, Gbagigi and Mawogi series. In 1958 treatments consisted of N and P at 0.3 and 6 cwt/acre, and in 1959 and 1960 all plots were split and K was applied at 0, and 1.5 cwt/acre.

On the Edozighi series, a heavy, peaty clay with an impervious clay subsoil containing 16 per cent org. matter, no significant responses to nitrogen were observed in 1958; the average paddy yield was 3438.4 lbs./acre. In 1959, with generally lower yields there was a significant response to N (P=0.05). N_1 and N_2 were both higher yielding than N_0. N_1 gave a greater yield than N_2, but the difference was not large enough to be significant.

Yields in 1960 were exceptionally high and showed the same order of response to N (P=0.01) and also a significant response to P (p=0.05) in the following order: P_2 P_1 P_0. No significant interactions between treatments were observed. It appears that the high initial fertility of the recently cleared "Kurmi" soils is declining gradually, although the unfertilised plots N_0P_0 still produced 3315 lbs./acre in 1960. The optimum application of N_1 P_2 however resulted in an increase of 1298 lbs./acre or 39.2 per cent.

The site on the Gbagigi soil series, a very clayey sand changing at 6″ depth to sandy clay and fine-sandy clay at 12″-15″ is representative of the levee soils along the Kaduna river. In 1958 and 1959 significant (p.=0.01) responses to N applications were obtained in the order; N_2 N_1 N_0. A yield increase of 60.6 per cent was obtained in 1958 and 32.3 per cent in 1959, when only half of the dose (N=3 cwt/acre) was applied. As these soils are very limited in extent and water control on this particular site was very difficult, the site was abandoned in 1960.

The soil profile of the Mawogi series shows a brownish grey sand to about 6″ passing into grey sandy clay with a compact, almost impervious fine-sandy silty clay layer of variable thickness occurring any where between 10″ and 30″. These soil series are modified river band deposits and representative of the slightly higher land above the levee.

In 1958 significant increases in yield could not be demonstrated because of a high coefficient of variability, although a distinct trend in favour of N applications was observed. Increases in yield of 12.4 per cent and 16.5 per cent respectively for N_1 and N_2 were obtained. In 1959, N_1 gave a significant increase in yields of 21.4 per cent ($p=0.01$) whereas N_2 resulted in lower yields than N_1, the difference was not large enough to be significant. Significant increases of 5.4 per cent and 16.8 per cent respectively were obtained with N_1 and N_2 in 1960 ($p=0.05$), compared with a yield of 2,839.6 lbs/acre from the controls.

Trial EA12(56)R59 was sited on the Badeggi soil series, the typical soil of the main flood plains. The profile consists of grey or dark grey sand passing into grey, very clayey sand until a sandy clay is reached at 15″. Treatments consisted of N and P at 0.2 and 4 cwt/acre in all combinations. In 1959 all plots were split for K which was applied at 0 and 1.5 cwt/acre. Examination of the data for individual years showed a consistent response to application of N. Highly significant responses of 29 per cent and 39 per cent respectively were obtained in 1959 with N_2 and N_4, the untreated control produced 1,792 lbs/acre. The difference between N_2 and N_4 were not significant. Responses in 1958 and 1959 were in the order N_4 N_2 N_0. N_2 and N_4 increased yields by 36.4 per cent and 57.1 per cent respectively, compared with a yield of 2,117 lbs from the control. In 1959 N_2 and N_4 produced increases 13.1 per cent and 21.2 per cent compared with the control which produced 2,440 lbs/acre. Results in 1960 showed the same trend with increases from N_2 and N_4 of 18 per cent and 29 per cent above the control yield of 2,025 lbs/acre. The trial will be repeated in 1961, when soil, leaf and grain samples will be taken for chemical analysis on N, P and K in order to study the efficiency of uptake of these elements.

The standard of the fertilizer trials has been good (coeff. var. not exceeding 11% in 1959 and 1960) : the yields on the controls generally were much higher than yields from the local farmers due to more efficient management of irrigation water.

Water Requirements.—Shallow water tanks have been constructed for the study of rice under various soil moisture regimes and the measurement of their water requirements. Results will be related to meteorological and climatological data. For this purpose evapo-transpiration rates for the Badeggi area are being determined. It is the intention to extend these calculations to areas where rice is liable to suffer from drought. Soil moisture testing apparatus has arrived and a preliminary field trial with direct seeded rice under limited water supply has been laid out in Badeggi, Shendam Lowlands and Jere Bowl to determine the relationship between planting method and soil moisture regime.

Legumes and grasses.—A collection of various grasses and legumes is maintained on the upland nursery at the station site to provide material for testing under fadama conditions.

A number of legumes and grasses were sown at the end of wet season on observation plots at the fadama. Growth and vigour during the dry season was better than expected, probably due to the fact that the ground water table

during the dry season remained high and never went below 6'. In growing legumes and grasses a way has been found utilising land in the season which would have been fallow otherwise. Of the legumes *Stylozanthes gracilis, Crotolania juncea, Crotalaria retusa, Vigna sinensis, Desmodium puris, Calopogonium Mucunoides, Centrosema pubescens* and *Sesbania speciosa* have been selected for a study of their possible value as green manure. *Pennisetum purpureum, Pennisetum pedicellatum, Hyperenia rufa* and *Andropogon gayanus* were selected to be tested as fodder grasses grown during the dry season to provide dry season feeding for station cattle.

Cattle Cultivation.—Cattle drawn implements for wet paddy cultivation have been designed and constructed and will be tested together with a various plough types. For this purpose a pair of bullocks have been acquired for which maize for silage and gamba-grass for hay making are to be sown in at an upland site on the station.

PATHOLOGY

Staff

The Virologist returned from leave in July, the Nematologist was on duty from his return from post-graduate training in August until his death in December. The Mycologist went on leave in September and returned in February.

Plant Disease Survey

Specimens of diseased plants have been received for identification from the following outside bodies :—Federal Department of Forestry Research ; Ministry of Agriculture and Natural Resources, Western Region ; Department of Agriculture, Southern Cameroons ; West African Cocoa Research Institute, Ibadan. Material has also been collected by officers of the Department when on tour, which together with information supplied by the Regional Departments of Agriculture as part of the F.A.O. World Reporting Service of Plant Pests and Diseases has provided a source of up to date information on the plant disease situation in Nigeria. Records of plant disease occurrence are filed under hosts and are being used for a revised list of Plant Diseases in Nigeria which is in preparation.

VIROLOGY

Cowpea Yellow Mosaic Virus

Vector—Virus Relationship.—Further experiments on the transmission of the virus by the Galerucid beetle, *Ootheca mutabilis* (Sahlb.) gave insufficient evidence as to the effect of the length of acquisition feed on the retention of the virus by the beetles. Certain difficulties were encountered in keeping the beetles alive while caged on cowpea plants. Following a one hour acquisition feed and daily transfers to healthy plants, 2 out of the 3 beetles alive after 10 days transmitted the virus, 1 out of 3 beetles after 11 days and neither of the 2 beetles after 18 days. This period of retention of the virus by the beetles is twice as long as has been previously recorded.

A new cowpea virus disease.—A virus disease of cowpea was mechanically transmitted from a plant showing mosaic symptoms collected from a locality in Ilorin Province in October. The virus has since been isolated from cowpeas growing at Mokwa, Niger Province and Ibadan.

Host Range and Symptoms

(*a*) *Vigna sinensis* (cowpea).—The symptoms on greenhouse inoculated plants differ markedly from those caused by yellow mosaic virus. In the variety New Era the symptoms are either masked or appear as a diffuse mottle. In the varieties Local White and Paraguay 6, an early symptom is a light green banding of the main veins. This feature sometimes remains when the leaves develop a light and dark green mottle. There is no distortion of the lamina or any reduction in leaf area.

(*b*) *Phaseolus vulgaris* (French bean) var. Comtesse de Chambord.—The virus causes veinal necrosis on the inoculated leaves and subsequently becomes systemic. Necrosis of the vascular system can clearly be seen and death of the plant occurs in severe cases. If the infection is only mild then the symptoms on the new growth, consist of a mottling with occasional necrotic flecking. Infected plants are stunted and there is a reduction in the size of the leaves.

Suspected virus disease of yams

Survey.—Surveying of the disease throughout the yam growing areas was continued in 1960. The first record of the disease from Colony Province came from Agege Farm where there was 33 per cent incidence in white yams.

Again Ilora and Share districts in Oyo and Ilorin provinces respectively were the only places where the disease was important in local farm fields. In both districts the incidence was less than in 1959.

Transmission.—It has not been possible to transmit the disease by tuber core-grafting with material collected from apparently healthy white yams and from plants showing symptoms of the disease. 99 out of 136 grafted setts germinated but only 17 of the 99 tubers used to supply "diseased" cores showed symptoms in their new growth. Subsequent growth of the material used in this experiment showed that the only grafted sett exhibiting symptoms in its new growth did not have its core supplied from a "diseased" tuber.

In a limited number of insect transmissions using *Coelidia Maculinervis* and two other unidentified leaf hoppers taken on yams, the disease was not transmitted from white and yellow yams to white yam seedlings. The new growth from the tubers of the seedlings used in this experiment was healthy.

MYCOLOGY

Over 100 collections of fungi were made during the period, the majority being examined at the Commonwealth Mycological Institute by the Mycologist during his vacation leave where duplicates have been deposited. The assistance of the staff of the Institute in identification is gratefully acknowledged.

The mycological herbarium has been arranged taxonomically using the method in use at the C.M.I. Foliicolous fungi and small specimens are kept in packets on herbarium sheets, larger specimens are stored in glass topped boxes. At present the specimens are kept dry by the use of a heater in the cupboard but it is hoped that it will be possible to move the mycological herbarium to an air-conditioned room in the near future.

Noteworthy fungus pathogens which have been studied during the period are listed below. (N.R.) indicates a new fungus record for Nigeria.

Cassava.—Glomerella cingulata (Stonem.) Spauld. and Schrenk, is common on cassava, causing leaf blotches and die-back of stems and has been recorded from Mokwa, Niger Province ; Lokoja, Kabba ; and Oturkpo, Benue.

Plyporus baudoni Pat. (N.R.), is apparently responsible for the serious stem and tuber-rot which has been recorded from Agege and Lokoja. Infected parts are covered with the characteristic orange-yellow mycelium, and orange coloured sporophores are produced at soil level.

Cowpea.—A disease referred to *Aecidium* spp., (N.R.) at C.M.I., collected at Ilesha in 1959, has so far not reappeared anywhere. Affected plants are covered with orange pustules and rapidly die.

Aristastoma oeconomicum (Ellis and Tracy Tehon, (N.R.) first recorded on Moor Plantation in November 1958 causing a leaf-freckle, has not been seen elsewhere in Western Region.

Colletorichum capsici (Syd.) Butl. and Bisby was associated with plants showing symptoms of stem anthracnose, in the Ibadan area, *Glomerella cingulata* (Stonem.) Spauld. and Schrenk, also occurred on plants in the same conditions.

Corynespora cassiicola (Berk, and Curt.) Wei, occurred commonly on plants on Moor Plantation causing zonate leaf spots.

Maize.—Blakeslea trispora Thaxt. (N.R.) was found on moribund leaves in April at Moor Plantation.

Epicoccum sp. (N.R.) occurred on dying leaves at Ibadan.

Corticium solani (Prill. and Delacr.) Bourd. and Galz (small sclerotial strain) caused a banded rot of leaves and leaf sheaths in July. The large sclerotial strain was also found, associated with cob-rotting.

Curvularia lunata (Wakker) Boedijn was recorded on leaves causing circular brown spots, and was of importance towards the end of the season.

Piricularia grisea (Cke.) Sacc. has been shown to be the cause of the leaf-spot disease which was severe on young plants in the field at the beginning of the 1959 and 1960 seasons. This is the first record of this fungus on *Zea.* The disease also occurred on seedlings being tested for rust resistance in a green-house and has proved difficult to eradicate from there. In scorings of varietal susceptibility to *Piricularia* the local, "Lagos White", was seen to be less heavily attacked than introduced varieties, in particular "Trinidad". This is in contrast to the higher resistance usually found in introduced varieties, particularly to rust (Puccinia polysora Underw.).

Yams.—Botryodiplodia theobromae Pat. was associated with large leaf blotches on *Dioscorea rotundata* at Ibadan and Ilaro respectively.

Cercospora carbonacea Miles causes black leaf spots which were very common on *D. cayenensis* and *D. rotundata* at the end of the season.

Cercospora contraria H. and P. Sydow, is almost always found on trifoliate yam. *D. dumentorum,* and other related wild species, causing a characteristic white-centred black spot, it was recorded from Victoria, Southern Cameroons; and Abak, Annang Province.

Corticium solani (Prill. and Delacr.) Bourd. and Galz. caused leaf lesions on all species of *Dioscorea* cultivated at Ibadan in times of heavy rainfall. This is easily recognised by the brown sclerotia in the centre of infection.

Pestalotiopsis sp. was recorded on leaves of *D. rotundata* at Ibadan.

Piricularia sp. (N.R.) was associated with leaf blotches on D. alata at Ibadan, this apparently undescribed species is being studied at C.M.I.

Spegazzinia tessartha (Berk. and Curt.) Sacc. var. *deightonii* Hughes (N.R.) was recorded on leaves of *D. rotundata* at Ibadan.

Grasses.—At Moor Plantation the following were recorded:—

Rust, on the common large bamboo, *Bambusa vulgaris* caused by *Uredo ignava* Arth. (N.R.); and on *Brachiaria lata* caused by *Uromyces leptodermis* Syd.

Piricularia grisea (Cke.) Sacc. caused grey leaf spots on *Eleusine indica,* this common weed is a possible alternate host for the maize pathogen.

Panicum maximum inflorescences were almost invariably infected with smut, *Tilletia ayresii* Berk. (N.R.) and frequently with false smut, *Cerekella andropogonis* Ces (N.R.).

Miscellaneous economic plants

Blighia sapida (Akee) was infected by *Mycosphaerella* sp. (N.R.) causing severe leaf-spotting at Ibadan.

Cauliflowers at Gombe (Bauchi Province), were heavily infected with *Alternaria brassicicola* (Schwein.) Wilts. (N.R.) causing a leaf blotch disease.

At Yola a leaf-spot disease of cabbage was caused by *Cercospora brassicicola* P. Henn (N.R.).

Oothyrium butyrospermi Syd. (N.R.) the cause of a conspicuous leaf-spot disease of shea-nut (*Butyrospermum parkii*) is common and has been collected from Zaria and Ilorin.

Rust of coffee (*robusta*) at Victoria Botanic Gardens, Southern Cameroons, was caused by *Hemileia coffeicola* Maubl. and Roger.

Cercospora citrullina Cke. was collected at Oturkpo, Benue Province, on pumpkin, causing leaf-spots, common.

Cacao seedlings from Victoria, Southern Cameroons, suffered from stem die-back, a species of *Nectria* was found on the bark but it was not possible to make a more definite identification with the material available.

Carrots at Oturkpo were heavily attacked by *Corticum solani* (Prill. and Delacr.) Bourd. and Galz., (small sclerotial strain), on the leaves.

The common shade tree *Gliricidia maculata* was almost invariably infected with *Helminthosporium* sp. (N.R.) and *Corynespora cassicola* (Berk. and Curt.) Wei, causing leaf-spots, at Ibadan.

The fungus causing yellow rot of cassava, *Polyporus baudoni* Pat. was also recorded on *Gmelina arborea* at Minna, on dying seedlings.

Helminthosporium heveae Petch, the cause of birds-eye-spot on rubber, was recorded from Banga, Southern Cameroons, and Ibadan.

An anthracnose and die-back of mango seedlings at Moor Plantation was associated with *Pestalotiopsis* sp. and *Pleurophragmium* sp. (N.R.) the pathogenicity of which has not been established.

Ustilaginoidea virens (Cke) Tak. occurred at the Federal Rice Research Station, Badeggi, but not commonly.

Pawpaw seedlings at Moor Plantation were infected with *Corynespora cassicola* (Berk. and Curt.) Wei, the cause of the common white leaf-spot on this plant.

An apparently undescribed species of Cercospora (N.R.) was associated with a striking leaf-spot disease of pepper, *Piper nigrum,* at Ibadan.

The following were recorded on sugar cane at Moor Plantation:—*Apiospora camptospora* Peuz. and Sacc. (*Papulospora* stage) (N.R.) and *Leptosphaeria sacchari* Breda de Haan, on leaves. *Schizophyllum commune* Fr. and *Pleocyta sacchari* (Mass.) Petrak and Sydow, on cuttings in the Quarantine house.

A leaf-spot disease of *Stizolobium deeringianum* was caused by *Cercospora stizolobii* H. and P. Sydow (N.R.) at Ibadan.

Fluted pumpkin (*Telfairia occidentalis*) at Victoria Botanic Gardens was infected with *Collectotrichum lagenarium* (Pass.) Ellis and Holst. (N.R.), on the leaves and stems.

Ustulina deusta (Hoffm. ex Fr.) Petr. was recorded on dead teak plants in the Ibadan Forestry Plantation.

At Zinna, Adamawa Province, bambarra groundnut, *Voandzeia subterranea,* was attacked by mildew, *Oidium* sp. (N.R.).

Stem-rot of banana associated with *Marasmius stenophyllus* Mont., is frequent at Moor Plantation in the early part of the wet season, and seems to be encouraged by the fact that water-shortage in the dry season is followed by water-logging with the onset of the rains.

The following new records of disease of ornamentals were made during the year:—

Asterina combreti Syd. leaf mould of *Quisqualis indica.*

Cercospora erythrinae Ell. and Ev. causing large leaf-spots on *Eythrina senegalense* at Ibadan.

C. daturicola (Speg.) Vassiljevsky, leaf spot of *Datura suaveolens* at Ibadan.

C. hydrangeae Ell. and Ev. the cause of the common purple leaf-spot on *Hydrangea* at Ibadan.

C. volkameriae Speg. on *Clerodendron thomsonii* causing leaf-spot, at Ibadan.

C. tageticola Ell. and Ev. on *Tagetes erecta* at Benin causing leaf-spots, associated with *Corynespora cassicola* (Berk and Curt.) Wei.

A conspicuous leaf-spot of *Randia maculata* was associated with a species of *Stysanus* at Ibadan.

PLANT QUARANTINE SERVICE

Staff

Four Plant Quarantine Officers under the direction of the Mycologist, and during his absence on leave from September to February, the Plant Pathologist, were on duty during the period covered by the report. One of the Plant Quarantine Officers was stationed at the Calabar Secondary Plant Quarantine Station, and one was stationed at Kano to supervise the setting-up of the Secondary Plant Quarantine Station there. The Mycologist attended the Fifth Annual Meeting of the Inter-African Phytosanitary Commission in October in London.

Facilities

The plans for the New Plant Quarantine Building at Ibadan, comprising office, laboratory, treatment room and facilities for soil sterilisation and fumigation have been approved and it was proposed to begin work in May 1961. The additional unit quarantine houses which will be built will vary in design to cater for different categories of introduced plants ; to begin with there will be one for seedlings and delicate cuttings, and three for sugar-cane and other tall-growing vegetatively propagated plants which do not require shading.

The sub-station at Calabar has been finished, and the Kano Station is nearing completion.

Plant Importations

102 Import Permits have been issued during the period. Potential sources of pest and disease introduction have been various unsolicited consignments of seed which have been sent to plant breeders and Departments of Agriculture in Nigeria. It would seem that there is still the need for a general awareness of Plant Quarantine on a world-wide basis, particularly among those who should not need to be reminded of the dangers of uncontrolled plant introduction, the agricultural botanists.

Importation of vegetative material of major crops during the period

Sugar Cane.—Two consignments of cuttings have been received into quarantine, from Australia and Kenya. Two consignments from Barbados have been released after growth in quarantine.

Coco-Yams.—One consignment from Trinidad was imported for the Botanist, Victoria Botanic Gardens.

Introductions

Plants of Pangola grass 'Digitaria procumbeas' from Trinidad, which were imported without an Import Permit from this Department were destroyed.

Unsolicited samples of wheat seed from Israel were found to be contaminated with rust spores and were given wet chemical treatment.

The aphid *Rhodobium rosaefolium* Theobald, was present on rose bushes imported from the U.S.A.

The ant, *Monomorium pharaonis* L. occurred on groundnuts, and the stored product weevil *Calasobruchus maculatus* F. was contaminated cowpeas, both from U.S.A.

Plant Exports

132 Phytosanitary Certificates were issued during the period of this report by the Plant Quarantine Service. There is still difficulty regarding the phytosanitary certification of bulk shipments of cotton, benniseed, timber, etc., and this will only be met by the provision of large-scale fumigation plants at the main Nigerian ports.

Most exports for propagating purposes have been in the form of seed as usual, and of these 11 consignments were of seed coconuts for the Philippines which were sent from Nigeria as part of the F.A.O. Coconut introduction programme.

Export of vegetative material to tropical countries

Coffee seedlings to Sierra Leone.

Rubber budwood to Ghana and Congo (Leopoldville).

Orchids and Sugar Cane to Ghana.

Legislation and Regulations

Draft Regulations under the Agriculture (Control of Importation) Ordinance, 1959 have been prepared, in broad conformity with the recommendations of the Inter-African Phytosanitary Commission and have been forwarded for consideration by the Minister.

Publicity

A Plant Quarantine label, which will serve to publicise the service as well as make plant importation easier has been designed on the lines of the one used by the United States Plant Quarantine Service. The draft of a publicity bulletin which explains the forthcoming new regulations has been sent to the Ministry of Information for printing.

HORTICULTURE

During the period of the report the horticultural work in this department has been done by the Plant Quarantine Officer when he has not been occupied with Quarantine work, which is given priority.

Economic Collection.—The work has mainly been routine maintenance of the plots. Composting or refuse is now done as it was observed that much valuable material was being carried away from the area when it could provide useful organic manure. Specimens of the *Crotalaria* and *Stizolobium* spp. were collected from the collection and identifications checked with the assistance of the Forestry Herbarium. *Euchlaena mexicana,* and three varieties of grape, *Vitis vinifera,* were added to the collection during the period of this report.

Ornamental Nursery

Maintenance of the small collection of ornamental plants has been done, and a few introductions have been made. The most noteworthy are:—*Lonchocarpus violaceus, Sabal bermudiana, Caesalpinia mexicana, Bauhinia galpinii* and *Salima carinalis.*

Avocados.—The varieties 'Chopuette', 'Lulu', 'Trapp' and 'Booth 7' have been imported from Florida and propagated by budding. In a trial of different methods of propagation, side grafting proved best, followed by shield budding both using beeswaxed tape. A consignment of budwood of other selected varieties from Florida arrived in a moribund condition, after being 17 days in transit, in October.

Kola.—In preliminary experiments on the vegetative propagation of Kola, no observable difference was noticeable with the use of rooting hormone ('Seradix'). 10 out of 20 six-inch-long, mature wood cuttings had rooted after 6 weeks under polythene sheeting in soil-sawdust mixture. Budding experiments gave the following results:—

Patch budding 12 out of 12 successful.
Shield budding (mature buds) 4 out of 12.
Shield budding (immature buds) 3 out of 6.

Further rooting test showed that cuttings of mature wood, split at the base and treated with hormone, were best with 4 out of 6 successful, but will be necessary to extend the experiments to provide more reliable data.

Pawpaw.—Varieties 'Black Solo', 'Hawaiian Solo' and 'Betty' were requested from Honolulu in May. It was reported that 'Betty' was extinct in Hawaii, as it apparently is also now in Florida.

The stock of 'Betty' consists of one female and ten males and selfing will be done to produce seed of this variety. 'Blue Solo' and 'Hawaiian Solo' have been introduced, and sown in Quarantine.

ENTOMOLOGY

Cereal Pests (Mr K. M. Harris)

Stem borers

Northern Region.—The studies of stem borers of cereals, which have been reported in recent Annual Reports, were continued.

At Samaru, Zaria the development of plots of early and late millet, guineacorn and maize was observed from planting to harvest. Each plot measured 1,000 square yards containing 1,000 stands of millet or 1,280 stands of guineacorn or maize.

In early millet 9 per cent of all stems present at harvest had been bored, mainly *by Coniesta ignefusalis*. The mean weight of unthreshed heads from stems which had not been bored was 0.142 lb. The mean difference of 0.028 lb. per head was highly significant and indicated a reduction of about 20 per cent in the yielding capacity of bored stems when compared with stems which had not been bored. However, since there were comparatively few bored stems in this plot, the overall reduction in yield resulting from stem borer damage did not exceed 2 per cent of the estimated potential yield which might have been taken if borer had not attacked the crop. On the other hand the regression of yield on missing stands was highly significant and indicated that loss of stand, which was mainly due to poor germination, had reduced the potential yield by about 16 per cent. Despite these effects of missing stands and stem borer, a good yield of 615 lb. grain on head was harvest from the plot (= 2,976 lb. grain on head per acre).

In the late millet plot borer attack was more severe and at harvest 45.8 per cent of all stems had been bored. Stand losses were also greater and amounted to 33.8 per cent of all stands planted and, in addition, downy mildew disease (Sclerospora graminicola) affected 20.6 per cent of the stands present at harvest. The analysis of stem borer data failed to indicate any significant effect on yield, probably because of the complex of other factors involved. 427 lb. grain on head were harvested from the plot. (= 2,066 lb. grain on head per acre).

The guineacorn plot suffered equally small stand losses but at harvest 91 per cent of all stands had been bored. Analysis revealed no relationship between borer attack and yield. 324 lb. grain on head were harvested from the plot. (= 1,586 lb. grain on head per acre.)

An additional experiment on guineacorn was made in conjunction with the Plant Physiology team. At harvest, random samples of ten stems per plot were taken from sixteen pairs of high and low fertility plots. High fertility plots had received 5½ tons of fym and 2 cwt. superphosphate plus 1 cwt. sulphate of ammonia per acre. Low fertility plots received 1 ton of fym and ½ cwt. superphosphate per acre. The observations made on the samples are summarised in Table 1.

Table 8. Summary of observations on Sixteen Pairs of High and Low Fertility Plots of Guineacorn

	Low Fertility	*Low Fertility*	*Mean Difference*
Mean % internodes bored per sample	26.62	22.73	3.89±1.02**
Mean number of pupal exit holes per sample	3.69	2.25	1.44±0.66*
Mean number of stems bored per sample	9.3	9.1	0.20±0.26 n. s.
Mean stem diameter per sample (cm.)	1.02	1.00	0.02±0.02 n. s.
Mean stem height per sample (in.)	96.2	86.4	9.8±1.1***
Mean wt. of grain per sample lb.	1.780	1.627	0.153±0.095 n. s.

Almost all stems had been bored by *Busseola fusca* and/or *Sessamia calamistis*. At harvest more than 90 per cent of all stems had been bored and, not unexpectedly, this measure of borer attack revealed no defferences between the two treatments. However, the other two measures of borer attack, which give better estimates of the damage done throughout the period of growth, show that borer attack was heavier on the high fertility plots. The subsidiary measurements of plant growth show that plants in high fertility plots were significantly taller than those on low fertility plots and the results of this experiment confirm previous observations of heavier stem borer attacks on large, high-yielding plants. There is now little doubt that, in the case of *B. fusca* attacking guinea-corn, well-grown high-yielding crops are more likely to be heavily attacked by borer than are poor crops.

Ibadan

A formal insecticide trial on stem borer control in second crop maize was carried out for the third successive year. This series is intended to compare the effectiveness of DDT, BHC and Aldrin dusts with that of an Endrin spray.

Once more the Endrin spray gave best control of attack by *S. calamistis* and *B. fusca* with a resultant significant reduction in the number of stands destroyed relative to the control. Aldrin and DDT gave a smaller degree of control. No significant increases in yield resulted from the control of stem borer and this was possibly due to adequate compensation for stand losses by the production of heavier cobs. The extent to which such compensation may cancel out the effect of borer attack is limited but, in this experiment, it was probably effective because borer attack was not severe. The results of the experiment are summarised in Table 9.

TABLE 9—STEM BORER CONTROL ON MAIZE, IBADAN 1960–61
SUMMARY OF FIVE PLOT TREATMENT MEANS.

Lay-out : 5 treatments x 5 replications. Randomised blocks.

Plot size : $\frac{1}{25.2}$ acres.

	DDT	*BHC*	*Aldrin*	*Endrin*	*Control*	*Significant difference*			
						5%	1%	0.1%	
Number of stands definitely destroyed by stem borer	9.2	13.2	8.4	2.2	18.6	8.0	11.0	15.0	**
Number of stands missing at harvest	52.0	43.0	34.0	25.4	63.8	20.5	28.2	39.0	**
Number of cobs	300.8	308.0	320.8	309.2	319.4				n.s.
Average dry weight of single cob (lb.)	0.270	0.273	0.260	0.244	0.277				n.s.
Weight of dry cobs (lb.)	81.15	84.05	83.25	75.30	88.50				n.s.
Shelling percentage	68.5	70.4	68.0	70.2	69.2				n.s.

Stem borer parasites

The following identifications were made by the Commonwealth Institute of Entomology during the past year:—

BETHYLILAE sp.

Goniozus sp.

Parasites of diapausing larvae of *C. ignefusalis* at Samaru.

FORMICIDAE

Dorylus affinis Schuck.

Ants attacking larvae of *B. fusca* in guinea-corn stems at Samaru.

CERAPHRONIDAE

Ceraphron sp.

Parasite of Syzeuctus sp. on *C. ignefusalis* at Samaru.

SCELIONIDAE

Telenomus busseolae Gahan

Egg parasite of *B. fusca* at Samaru.

PYEMOTIDAE (Acarina)

Pyemotes ventricosus (Newport)

Parasite of diapausing larvae of *C. ignefusalis* at Samaru. Particularly troublesome in laboratory cultures.

Sorghum midge

The results of preliminary investigations of the sorghum midge (*Contarinia sorghicola*) have been written up and submitted for publication. Further development of these investigations is envisaged but has not been formulated and, as a result, little work was done on this pest during the past.

YAM BEETLE

Biology and Control

W.A.I.F.O.R. Light Trap

The light trap was operated from 1st April, 1960 till 2nd January, 1961. It was switched on at 7 p.m. and continued either till 8.30 p.m., or till 30 minutes after the last beetle was recorded, whichever was the later, instead of operating from 7 to 9 p.m. nightly as in previous years.

The first beetle was taken at light on 8th April and 1,759 beetles were taken between that date and 15th July when the last beetle was recorded. The number taken in April, May, June and July was 1,164, 580, 11 and 4 respectively; 1,650 beetles (or 94 per cent) were taken between 13th April and 12th May. Flight this year was more closely grouped than in previous years. In both 1958 and 1959, more than 100 beetles were recorded in June and there were more than 50 beetles on one night in both months.

The pattern of flight was observed more clearly with the new method of recording. The time of onset of flight was usually between about 7.00 and 7.30 p.m., being earlier or later according to whether number of beetles flying that night was large or small. Similarly the time beetles stopped flying varied according to the size of flights, big ones ceasing later than small ones; the latest beetle was recorded at 10.34 p.m. Duration of flight on any one night also was related to number of beetles flying. Beetle flight began and stopped quickly and the number of beetles flying per unit time was more or less constant throughout.

Of the 1,759 beetles flying, 402 (23 per cent) flew after 9 p.m. and of these 345 flew on two nights on both of which nearly 400 beetles were taken at the light trap. It is possible that beetles taken at the light trap after 9 p.m. in April and early May would have flown again in May and June if they had not been taken in the light trap and given a similar picture to last year's.

During the return migration only 20 beetles were attracted to the light trap between 14th November and 12th December. The reason for this small return migration after such a large migration in April is not understood. It is possible that the light trap efficiency, operating nightly until yam beetles had stopped flying, was so great that it affected the number of beetles attacking yams (the attack rate in the observation plot was very low) and so reduced the number of beetles flying in November.

Onitsha Light Trapping

Observations on the number of beetles flying to light at a large street lamp in Onitsha town were made from 4th April until 23rd August and from 20th October to 19th December. Only 96 were taken in the early period, 2 in April, 54 in May (43 on the 31st), 43 in June and 6 in July. Flight effectively began on 31st May and 76 (79 per cent) of the whole were taken between 31st May and 10th June.

The return flight began on 6th November and ended on 25th November and during this time some 1,727 beetles were taken.

This is considerably greater than was taken the season before and considerably more than in April-June this year. It is observed that each year more beetles are taken in April to June than in November to December at W.A.I.F.O.R. while the reverse holds good at Onitsha.

The reason for this is not understood but it would appear that more beetles are attracted to light in the area towards which beetles are flying. Thus in November beetles are flying to the breeding areas near Onitsha while in April to June they are flying away from the breeding areas towards the yam fields such as at W.A.I.F.O.R.

Bori Light Trap

At Bori in Rivers Province, a Tilley Lamp was operated as a light trap from 25th April till 23rd December. Three species were taken at light namely, *Heteroligus meles Rillb, H. appius* Burm and *Prionoryctes canaliculus* Arrow. The number of each recorded is as follows:—

	25 April -7 May	*May 8-15*	*May 16-24*	*May 25-31*	*June 1-7*	*June 8-15*	*June 16-23*
H. meles ...	—	3	8	6	—	2	1
H. appius ...	—	2	—	3	—	—	—
P. canaliculus ...	—	1	3	3	—	—	—

It will be seen that in this area the flying periods of the 3 species are roughly the same. This is the first information available on the flying of *P. canaliculus*. *H. meles* may fly later in this area than at Benin.

During the late season at Bori only 3 beetles were taken, one *H. meles*, on 21st October and one on 6th November and one *P. canaliculus* on 13th November. Again it would appear that, as at W.A.I.F.O.R., more beetles are seen at light during the migration to the yam fields than in the November period.

Control

Spraying Observation at Umudike

A plot of yams was planted at Umudike for use in testing the effect of various insecticides sprayed onto the surface of the yam hills upon beetles which burrowed into the yam hills thereafter. The phytotoxicity of sprays was tested first and it was found that slight burning of new shoots took place with emulsion concentrates at the following strengths: Dieldrin 1.05 per cent and Aldrin 1.05 per cent. No wettable powders caused damage to yam plants.

The technique of testing finally adopted was to spray the hills between 10 and 11 a.m. for a radius of 6 inches from the base of the plant as beetles usually enter the soil within this distance. The next morning between 6 a.m. and 8 a.m., depressions up to $\frac{1}{4}$ inch deep were made into the surface of the soil to ensure that beetles burrowed into the yam hill in the right direction, and 8 beetles were placed into the depression. They were dug up again after 24 hours exposure to the insecticide on the 3rd morning. A number of beetles usually strayed and were lost, and at least 8 beetles per hill were needed to test the effect of insecticides. If less were used, the numbers recovered were too small to give an estimate of the effect of the insecticide.

The number of beetles dug up was recorded and they were put into jars with clean moist soil and yam to feed on and the jars were inspected daily and the number dead were recorded. Early results were very variable and the number of insects needed for any trial was high in relation to the number that could be collected and bought and by the time a suitable technique was worked out, all beetles had been used. It is more effective to cover sprayed yam hills than to leave the sprayed surface open to sun and rain. The volume of spray given appears to be important.

Five experiments were laid down this year with two main objects in view. The first was to find out whether yam beetle attack upon early planted yams could be controlled by mixing Aldrin with the soil in the planting holes and the second to compare several strengths of BHC and Aldrin used as seed dressings on late planted yams.

Experiments upon Early Planted Yams

Experiments, begun in the Northern Region, showed that 2.5 per cent Aldrin dust mixed into the soil of the planting holes gave some control of yam beetle damage in 1959 at the rate of one ounce dust per acre. It was decided to lay down trials to try this method in the South in an attempt to control yam beetles on early planted yams. Two areas were chosen, near Aguleri on the alluvial plains on which yam beetles commonly breed, and in Ogoni Division.

Aguleri

This experiment was planted on 25th February and was only laid down with much trouble. The soil was very clayey as is usual in this type of country, and mixing insecticide with it was extremely difficult as the soil was dry and not easily broken up.

Although the attack rate was very low (5.5 per cent untreated yams attacked) the experiment still showed that treatments had decreased damage although the variation of such a low attack rate was high and the differences were not statistically significant.

A similar decrease in damage was obtained when one quarter ounce Aldrin dust per plant is mixed with the soil as when one eleventh ounce was used as a seed dressing.

The yields obtained following the different treatments were not significantly different since so low an attack rate would not appreciably affect yields.

The use of insecticides also increased the number of bearing stands presumably by killing off yam beetle larvae early in the season.

Bodo 1960

This was a similar experiment to that at Aguleri except that the one ounce soil mixture was omitted. In this trial one eighth ounce Aldrin mixed with the soil reduced damage by a similar amount (24 per cent) to one tenth ounce seed dressing, and higher rates of application (one quarter and one half ounce per yam) caused greater reductions in damage.

Satisfactory yield increases were obtained as the attack rate was high (88 per cent stands attacked). There was no significant difference between yield increases obtained by the different treatments.

Bori Experiment

An experiment similar to that at Aguleri was laid down except that Dieldrin was also used so as to compare the two dusts. The experiments showed no significant difference between Aldrin and Dieldrin, although plots treated with Aldrin gave a yield 19 per cent greater and an attack rate 7 per cent lower than those treated with Dieldrin.

In this experiment and that at Bodo the soil was sandy and the insecticide mixed easily with it. The experiment was planted on 25th January and although seed dressings do not usually control yam beetle damage at such planting dates damage was decreased by 44 per cent at the rate of one tenth ounce dust per yam.

Thus two and one half times as much insecticide was used when mixed with soil to produce the same effect as the seed dressing.

Aguleri

A second experiment at Aguleri designed to compare 2.5 per cent Aldrin dust was a failure because of low attack rate, no untreated yam being attacked.

Ihialla

This experiment was designed to compare 2.5 per cent Aldrin dust with various strengths of BHC. The results show that with a low attack rate, all

treatments reduced damage though not significantly and that all treatments significantly increased yield.

This experiment gave reason to change the recommendation that 2.5 per cent Aldrin dust be used as seed dressing to control yam beetles on late planted yams.

Summary

The experiments on mixing dusts with the soil in the planting holes indicated that it is possible to control yam beetle in this way and that with early plantings better control can be obtained in this way than with seed dressings. The cost however is greater since more insecticides must be used and application may often be difficult.

It might be worthwhile for Agricultural Officers to consider in the light of conditions in their own areas whether further trials would be of interest to farmers in view of the increased expense and trouble.

Studies on Whitefly (Mr L. A. Mound)

Introduction

The programme of work carried out this year was a continuation of that indicated in the report for 1959-60. During the year, more information has been obtained on the behaviour, population variation, and in particular the taxonomic identity of *Bemisia tabaci* Genn.

Behaviour

The studies on colour sensitivity have been concluded. *Bemisia* is highly sensitive to two groups of wavelengths of light, 0.50-0.55u, and 0.35u downwards. With the apparatus available it has not proved possible to define any more accurately the regions of sensitivity. However it is important to note that these two groups of wavelengths are regarded as being complementary in character. This is probably the physiological basis behind the flight behaviour of adult whitefly. The insects are activated by the morning sun and fly upwards attracted by the ultra-violet radiation. Later they become repelled by this or more accurately, attracted by yellow, the complementary colour. This would explain the greater importance of yellow as opposed to green in the host selection process.

Sticky yellow traps have been used for studying flight periodicity in the field. These were cleared at hourly intervals over most of the year. The catches were found to be greatest between ten and eleven in the morning, and between four and five in the afternoon. This apparent double period of flight activity was not seen in the results obtained with a suction trap. A Johnson Type trap was operated near the yellow traps, but this only shewed a single daily peak of activity, in the morning. The difference in catches between the two types of trap may be a reflection of the host selection behaviour. It seems likely that the afternoon peak is the result of whitefly returning to the crop from a flight high in the air. Such a return flight, if it is actively directional, might not be reflected in the suction trap catch to such an extent as in the yellow trap catch.

The colour sensitivity, and vision in general, is not sufficient to explain host selection behaviour. A recent suggestion for aphids is that the power of sight merely assists the insects to find the right group of plants, *i.e.*, dicotyledons instead of monocotyledons, or vice versa. This could well be true of *Bemisia.* The

mechanism by which a host is finally accepted would then be of a chemical nature. There is no evidence to suggest that an olfactory sense is in any way important (*see* 1959-60), and so it seems probable that hosts are recognised and accepted through some sense of taste. In an endeavour to investigate this, experiments are in progress on feeding whitefly through an artificial membrane. A very fine latex membrane, which has been used with other Homoptera, was found to be too coarse. Some success was obtained with certain plant cuticles, but much more promising is a very fine membrane which has recently been received, derived from goat mesentery.

Population Study

Reports of insecticidal spraying against whitefly on cotton in the Sudan have stressed that it is not uncommon for a whitefly population to increase after such treatment. This has not been found to be the case in Ibadan on cassava. This could be an indication of the difference in the importance of natural biological control in Sudan and Nigeria. Parasites here are usually rather scarce. *Prospaltella* sp., (near *strenua* Silv. according to the U.S. National Museum) the only recorded parasite, is rarely found in more than 20 per cent of the pupal cases of *Bemisia* in the field, and usually in far fewer. *Serangium cinctum, a* predatory Coccinellid, has been found to be very limited in the period over which it will attack whitefly. This year it was only seen for about three weeks in July. A parasitic fungus is not uncommon towards the end of the rainy season on whitefly pupal cases, but was not seen this year. However a Typhlodromid mite was recorded for the first time as a very effective predator of larvae during the rainy season. This was identified by the British Museum as *Typhlodromus* (*Amblyseius* sp. (*finlandicus* group). Two or three were found on each cassava plant and each one was able to eat several whitefly larvae. This mite was probably responsible for the low population of *Bemisia* found throughout the rainy season. It has previously been claimed that the whitefly population is at a minimum during the dry season and rises rapidly after the onset of the rains. This was not true for the past year, the population being large through the dry season and falling with the onset of the April rains. The maximum population eventually developed in June, but this was followed by a sharp decrease to a low population, which was maintained throughout the rest of the rains and also into the following dry season. Very probably the seasons have little effect on the population level directly, but act through their effect on the host plants. During the dry season 1959-60, the cassava grew well in most places due to early planting. In 1960-61 dry season however, there was little available cassava which was growing vigorously, as most of it had been planted late or else was already growing old.

Taxonomy of Bemisia

The identity of the various species of *Bemisia* has been a matter of some discussion for many years now. Russell (1957) of the U.S.D.A. synonymised several species with *B. tabaci* but gave no indication of what the status was of various described forms. Assuming the accuracy of the original descriptions, the possibility existed that these forms were genetically determined and had different behaviour patterns, and possibly carried different viruses.

To examine this problem an inbred clone of *Bemisia* was raised from a single virgin female on cassava. The clone was kept in complete isolation and was not subject to contamination from any outside source. The whitefly were permitted to breed on the Cassava and on the following plants enclosed with it ; *Dolichos lab-lab,* Tobacco, Cotton, *Centrosema* sp., and *Hibiscus* sp. The pupal

cases, on which whitefly species are based, were found to be highly variable within this clone. More importantly each host was found to have a form of pupal case specific to it. Thus the Tobacco and *Centrosema* specimens were very hairy, the *Dolichos* specimens glabrous, the Cotton and *Hibiscus* specimens glabrous with pronounced wax glands. Forms were raised on these plants which corresponded with several described species of *Bemisia,* all of which have been synonymised by Russell with *B. tabaci.* It therefore appears that these forms are not genetically determined but are actually host induced. This taxonomic problem of host induced variation is not uncommon in the Aleyrodidae. Detailed results are to be published elsewhere, but it can now no longer be claimed that the so-called Cassava, Tobacco and Cotton Whitefly are separate biological entities.

Very large collections of whitefly were made this year during tours in the Northern and Eastern Regions. It is hoped that it will be possible to identify or describe some of this material during visits to the British and the United States Museums. Collections of *Bemisia tabaci* during these tours were remarkable in that no geographical variation in the pupal cases was found. This species, although highly variable morphologically, seems to be genetically very stable. This may be due in part to its great powers of dispersion. However another species of *Bemisia, B. hancocki,* was found on Cassava at Bida. This has also been received from Bamenda ; Njala, Sierra Leone ; and Yambio, Sudan. There is some evidence to suggest that this species is indigenous here, and that *B. tabaci* is a relatively recent introduction. This is supported by the recent (1930-40) great spread of Cassava Mosaic, and the fact that this disease, and also its vector *B. tabaci,* is almost unknown at Njala, whereas on the coast at Sierra Leone they are both common.

Whitefly Bemisia spp. (Mr F. A. Squire)

Investigations proceeded on the incidence of the pupal parasite *Prospaltella* sp. on *Bemisia tabaci* (Genn.). Previous observations indicated that the incidence of parasitism in the field and even in greenhouses hardly ever rises above 25 per cent and this gave rise to the question of the possible existence of a dominant resistance factor. In order to test this idea it was necessary to subject *Bemisia* populations to a severe challenge by *Prospaltella* in captivity to see whether the 25 per cent barrier could be crossed. The procedure was simply to raise *B. tabaci* on young cassava plants in greenhouses and introduce *Prospaltella* in quantity and allow to breed freely. Samples were examined at monthly intervals. In order to facilitate counting the estimate of parasitism was based on empty pupal cases. Individuals previously parasitised are easily distinguished by the circular exit of the parasite as opposed to the Y shaped rupture of the pupal case made by the emerging adult *Bemisia* and also by the black remains of the parasite's pupal case and red fluid excreta which are quite conspicuous. The following table shows the progress of parasitism:—

	Month	*Total No. of cases examined*	*No. Parasitised*	*Percentage parasitised*
1960	May	1,009	203	20.1
	June	3,790	2,491	65.7
	July	7,156	3,628	50.7
	August	5,660	1,310	23.2
	September	11,105	3,522	31.7

It will be seen that the high incidences of parasitism in June and July do not support the theory of a dominant resistance factor in the host population.

THE COLA BRANCH BORER

Investigations were continued. The Lamiid beetle *Phosphorus virescens* (Oliver) var *jansoni* Chevrolat was kept under observation in cola groves near Aredi during the whole period. The full grown larvae last reported on in this locality pupated and emerged and gave rise to a very large adult beetle population. Eggs laid early in November 1959 hatched in December and by January the young larvae were making rapid progress down the young shoot towards the branches. Larvae of all stages were collected for future study and head measurements were taken to work out the instars.

It is evident that there is a great deal of variation in the rate of growth of larvae which might easily give rise to the mistaken impression that there is more than one generation a year. The range in size is, however, partly due to the spread of the oviposition period which though not accurately known is probably of the order of a month or two.

It will be recalled that a controlled experiment with Rogor 40 was carried out in October 1959 and that the results were somewhat unsatisfactory owing to the age and position of the larvae in the older woody tissue. On 7th March, 1960 a second trial was carried out at Aredi. By this time the very early larval stages were passed and the trees were inhabited predominantly by 3rd and 4th instars many of which had already penetrated into the 2nd year growth. It was, therefore, considered that the optimum time for applying the treatment had in fact elapsed rather more quickly than was thought possible. Nevertheless results showed that 25 per cent of the larvae in the treated trees were dead ; dead and obviously very sick larvae amounted to 50 per cent as against nil in the controls. A third trial was conducted in the same locality on 4th April, 1960. By this time the larval population was still more advanced and were mostly located in branches an $1\frac{1}{2}''$ or more in diameter.

In addition there were fairly frequent showers so that in view of the slow absorption of Rogor 40 by foliar tissue success was hoped for but not expected. Larvae examined on 9th April, 1960 showed that there was no difference between specimens taken from treated and untreated trees.

A fourth experiment was laid down at Moor Plantation on larvae transposed from Aredi into *Cola nitida C. acuminata* and cocoa, on 6th May. There was a heavy shower of rain within 12 hours of spraying. Results of this experiment showed no significant difference between treated and untreated trees.

A further trial was started on 5th December, 1960, 10 cola trees being sprayed with Rogor 40 at a concentration of 1/200 so as to produce complete foliar cover. Ten control trees were selected. Four samples were taken at different intervals after spraying and the results are shown as numbers of larvae alive and dead in treated and control trees.

Sample Days After Spraying	*Treated*		*Control*	
	Alive	*Dead*	*Alive*	*Dead*
7	5	9	13	2
14	5	5	10	2
23	3	4	12	2
30	3	3	10	3
	16	21	45	9

Owing to their meagerness the results of the four samples are lumped. There is a significant difference at .01 level between treated and controls.

It was, therefore, concluded that Rogor 40 is probably capable of control in a single foliar application at 1/200 concentration provided it is applied while the larvae are still in the translocatory tissue and during dry spells so that the insecticide is not washed off by rain before it is absorbed into the plant. The best month of spraying is January.

In order to facilitate biological observations larvae were transposed from *Cola nitida* at Aredi to *C. nitida C. acuminata* and cocoa at Moor Plantation. Apart from the larvae used in the fourth experiment 87 other larvae of different sizes were transposed from Aredi to Moor Plantation for general biological studies. It is worth noting that these larvae live quite happily in *C. acuminata* which is not usually attacked in nature. An interesting observation worth recording is the fact that while larvae always move down the branches towards the central axis this is really associated with gravity for in older trees with dropping branches inserted larvae often move downwards away from the central axis towards the distal end of the branches.

It was noticed that the moist conditions set up in many of the burrows by the early rains resulted in the death of some of the larvae by drowning in a mixture of mucilage and water that had accumulated in the burrows.

A species of Braconid parasite was bred out from one of the larvae in *C. nitida* at Moor Plantation but it is possible that the parasitised grub belonged not to *Phosphorus virescens* but to another Lamiid borer sometimes associated with Phosphorus, *viz: Aethiopichamus ruficornis* Hintz.

During a visit to the Southern Caremoons from 10th to 24th February, 1960, cola trees were examined in the vicinity of Victoria, Buea, Tiko, Kumba, Mamfe and Bamenda. There were no signs of *Phosphorus* attack which was not surprising as most of the cola in this region is *C. acuminata.* In the Botanic Gardens at Victoria, *Phosphorus* larvae were found in some old *C. nitida* trees.

An ant *Crematogaster* sub. gen. *Acrocelia* sp. was common in *Phosphorus* burrows where it appears to act as a scavenger. Dipterous larvae live as ectoparasites on the mealy bugs also present in the burrows.

In the course of routine dissection of adult beetles collected in the field mostly from the Aredi cola groves a remarkable larval hymenopterous parasite was discovered living free in the lower abdominal cavity of some of the beetles of both sexes. These parasites, often as many as 60 or 70 but as few as 2 or 3 in some cases, appear to live on the abdominal fluid without attacking the vital

organs. There was no evidence that they are responsible for shortening the life of their host but the latter is short lived whether parasitised or not and a point of special interest which came to light is that the parasitic larvae evidently cannot complete their life-cycle on this particular host (although the end of the larval stage appeared to be reached in some cases) but apparently succumb within a few hours of the death of their host. At all events they defied all attempts to breed them through to adult wasps. The tentative conclusion was therefore formed that *Phosphorus* is in effect a false host of this parasite. The same or a similar parasite was found in another Lamiid ecologically associated in the cola groves with *Phosphorus* namely *Sternotomis* which lends colour to the false host theory, but efforts to breed the adult parasites out from *Sternotomis* were also unsuccessful.

The presence of parasitic larvae in the abdominal cavity of adult beetles apart from nematodes has not, as far as can be ascertained, been hitherto recorded. Such an unusual observation therefore seemed to call for further investigation. During the months of October and November when the beetles were numerous in the cola groves 149 beetles were dissected and the following results recorded:—

TABLE 2.

	Infected	*Not infected*	*Total*
Males	19	47	66
Females ...	30	53	83
	49	100	149

There was no significant difference in the rate of infestation between the sexes. It will be seen that the overall incidence of parasitism was 32.9 per cent. This high degree of parasitism does not support the false host theory.

From this discovery the natural step was to investigate other Cerambycid coleoptera. As so often happens in such cases there was a perverse scarcity of Cerambycids normally fairly well represented in light trap collections. Efforts were, however, rewarded with the discovery of a massive micro-nematode infestation in the abdominal cavity of the large familiar prionid *Mallodon downesi* Hope. Specimens of these nematodes were dispatched to the British Museum (Natural History) and the matter will receive further attention.

Doubt surrounding the process of oviposition was cleared up during the latter half of the year. The females first of all sever the growing tips below the 3rd or 4th leaf and often proceed to ring bark it an inch or more further down which ensures the necessary dieback. The egg is then inserted singly axially in the pith. The egg which is long and narrow and slightly curved averages some 3.5. mm. in length. It is pale cream in colour and has a tough integument resembling parchment. The length of the egg period was not accurately determined but does not exceed three weeks according to the results of field sampling.

Oviposition takes place during the months of October and November. Routine sampling in the cola groves at Aredi and elsewhere even so far away as in the Eastern Region near Umuahia clearly indicate that the egg stage is virtually over by mid-December.

During the process of hatching, the young larva feeds on the inner layers of the egg shell and later on parts of the outer integument as well. Later still sheltering in the remains of the shell it begins to tunnel in the surrounding dead plant tissue for the whole of the first larval instar. The larval head capsule on emergence measures 0.75 mm. in width. At the 2nd instar it is 1.50 mm.

At this stage it leaves the dead tissue and migrates axially in the proximal direction into the green living part of the shoot, eating its way more or less down the centre. Here it encounters the danger of the flow of mucilage which can easily engulf it.

The larva however successfully meets this danger by cutting circular drainage vents every half inch or so according to need as it tunnels down the shoot, and the size of the holes increases with the width of the head capsule. These apertures with their exudate of gum and frass are very characteristic of *Phosphorus* attack.

The larval instars have not yet been worked out but it has been ascertained that during the nine months of larval life the head capsule width increases from 0.75 mm. to 10.2 mm., growth being very rapid while the larva is living in soft green tissue. As it leaves the first year shoots and works towards the main axis it encounters woody tissue and progress both in distance tunnelled and in growth is much slower. The larval habit of eating its exuviae makes it difficult to determine the number of instars but a study of long series of head capsule measurements suggests that there may be as 10 larval instars. More biometrical data are required especially over the last three or four instars before more definite conclusions can be drawn.

The pupal stage was investigated by transplanting well grown larvae from cola in the field into cola and cocoa trees on Moor Plantation using a technique which permitted of periodic inspection with the minimum of disturbance. Pupation took place during the months of July, August and September and the recorded length of the pupal period based on some 50 observations was 15 to 42 days with the greatest frequency at 28 days. There was no apparent difference according to host-plant.

Observations were also made on larvae kept in sections of branches of cola and cocoa which were renewed from time to time. These gave similar results.

Some 60 larvae were introduced into coffee trees on Moor Plantation. Of these 46 died and the remaining 14 have not yet pupated.

The full grown larva prepares for pupation by constructing a pupal chamber in the woody tissue. The last frass and shreds of ligneous fibres accumulated in the burrows are packed down at the tail end of the chamber and the last exuvia is deposited on top of this detritus during pupation.

The adult beetle on emergence from the pupa is of a uniform dirty slate colour which gradually differentiates to produce the brilliant green-yellow and black pattern which characterizes the genus. It is only after several days when this has taken place and when its jaws have hardened that the beetle chews its way out of the pupal chamber and joins its fellows to form a fairly numerous but short lived community of adults in the cola groves during the months of August to November. Only a few appear in August but September and October are peak months. By mid-November it is difficult to find a single specimen.

Mating is lengthy, repeated and tenacious with the male dorsally superincumbent. The male copulatory tube is nearly half an inch long and encloses a heavily chitinized tendon attached ventrally to the inner wall of the anterior abdominal exoskeleton and ending distally in a bifid claw which is evidently anchored in a similar less heavily chitinised tendon extending from the vagina apex to the anterior ventral abdominal inner surface of the exoskeleton of the female.

Dissections carried out during September, October and the early part of November showed that contrary to belief hitherto, egg development does not take place while the female is still enclosed in the pupal chamber but only some time after emergence into the outer world. Many of the females showed no trace of egg development during the early part of this period. Later the percentage with good egg development rose steadily until towards the end only spent females were taken. Up to 50 or more eggs per female are produced. Associated with this is the fact that active spermatozoa were observed in the spermathecae only during the middle and latter part of adult activity.

Similarly males dissected during the early part of this period clearly demonstrated that spermatogenesis was incomplete and it was only later that active spermatozoa could be detected in the testes.

Although they are capable of sustained flight if disturbed, the beetles seem relatively inactive and prefer normally to sit high up in the cola trees clasping the green shoots and feeding on the young bark. As the result considerable scarring takes place which later develops into cankers. Both males and females will in certain circumstances feign death and this peculiarity can be exploited to advantage in collecting them from the field. If a stick is pointed at them they will invariably fall straight down to the ground where they lie inert and are easily collected.

Population sampling was carried out at Aredi during the months of July to December at Aredi, Fiditi, Araromi Egbeda, Moor Plantation in the Western Region and at Ariam and Aba in the Eastern Region. The object was to take a sample census of the various stages during this period and to see what locality differences occur. Considering the latter first it was found that there were no locality variations, the different stages of development occuring everywhere more or less at the same time. The results are summarized in the following table:—

	Larvae (old cycle)	*Pupae*	*Adults*	*Eggs*	*Larvae (new cycle)*
July	87	1	1	—	—
August	101	78	30	—	—
September ...	7	21	202	—	—
October	—	—	155	53	90
November ...	—	—	4	47	301
December ...	1 (in chamber)	—	—	15	106

This clearly demonstrates that the *Phosphorus* year starts in October when eggs first appear. If, therefore, control is envisaged by action against adult beetle, it should be taken during September when they are most numerous and before the commencement of oviposition. But if control measures are to be directed against the larvae for example by means of systemic insecticides then December and January are the optimum months. By this time most of the eggs have hatched

and the young larvae will have penetrated the young translocatory tissue some way proximal to the youngest leaves so that they will be found by the insecticide as it travels from the leaves towards the main axis. Moreover these are normally dry months favouring the maximum foliar absorption of insecticide.

THE COFFEE TRUNK BORER

Another Cerambycid of economic importance is the coffee stem borer *Bixadus sierricola* (White). In this case only the lower trunk is attacked the larval point of entry being one to two feet above the ground. Tunnelling takes place at first in the bark more or less horizontally in a circle round the trunk and then downwards through the woody steel into the tap root. The infestation may be multiple and trees are often killed or reduced to complete unproductiveness.

Observations both in Western Nigeria and the Cameroons brought some important facts to light. Both *robusta* and *arabica* varieties are equally liable to attack. But signs of infestation are hardly ever seen in well kept farms and plantations. The infestations were observed in unweeded and excessively shaded farms. Such conditions are all too common and are associated with mixed cultivations of coffee with cocoa, bananas, plantains, avocado pear and tung as well as other shade trees. Since coffee needs only light shade the answer to the coffee trunk borer is to grow the other crops elsewhere and to keep the coffee farms reasonably weeded especially during the rains when the adult beetle is active.

ODONTOPUS

Observations were continued on the Pyrrhocorrid *Odontopus sexpunctatus* Lap. on *Hildegardia barteri* trees at Moor Plantation. Resting colonies remained sheltering on the under side of the main branches until the first week in November when the first breath of harmattan sent the leaves to the ground. They then broke up and descended to the ground taking shelter under the leaf litter where copulation was soon in evidence. During the whole of this period up to the end of December no feeding was observed. A few nymphs appeared under the leaf litter in December. By mid-January the old generation of resting adults had disappeared and nymphs of the first generation were much in evidence. This was puzzling because there was nothing for them to eat. No feeding was observed yet they continued to grow. At this time the *Hildegardia* trees burst into flower. Single pea-like seeds in thin papery pods were produced in great abundance and shed early in February. Still no feeding was observed although it is assumed that some took place since many of the new generation were now in the adult stage and there were indications that another brood was imminent. It was not until the fruits were quite dry and hard and the pods partly decomposed that feeding become general. A rapid increase in population followed and breeding continued during February, March and April with overlapping generations. It is estimated that at least three generations were produced on the ground.

On 26th April, 1960 the first resting colony of approximately 100 adults and late nymphs was observed on the underside of one of the larger *Hildegardia* branches. The number of colonies steadily increased in size and numbers and by the end of May almost the entire population of some thousands of adults and late nymphs had ascended the trees and settled down in some ten separate colonies.

Thus it is evident that *Odontopus sexpunctatus* is active for only approximately five to six months in the year. Feeding is confined to an even shorter period of some three to four months. The period of activity coincides with the dry season and with the fruiting of their host plant.

APHID AND PSYLLID POPULATION STUDIES

Nothing has been reported on this subject since 1958 due to the absence from the British Museum (Natural History) of the officer responsible for the determinations, Dr V. F. Eastop. The latter has since returned and has worked through the accumulated collections and provided the identifications together with the relevant numerical data. It is therefore desirable to review the position briefly for the past two years, that is up to the end of 1960. The peak months for both aphids and psyllids according to the incidences recorded by the yellow trays are the month of August and again from November to February, *i.e.*, the short break during the rains and the dry season. The heavy rains, even those in March-May appear to be inimical to these insects.

Eleven species of aphids are taken regularly in most months of the year and have been named. The most important numerically are:—*Pentalonia nigronervosa*, the vector of bunchy-top of bananas a disease not recorded in Nigeria, *Toxoptera citricidus*, *Aphis gossypii*, and *Schoutedenia bougainvilleae*. Eleven other species are recorded only on comparatively rare occasions.

Four species of psyllids were recorded. Of these *Mesohomatoma tesmanii* was common throughout the period. *Phytolima lata* the gall former on *Chlorophora excelsa* appeared in considerable numbers in May and June 1960 and was scarce for the rest of the period.

CITRUS FRUIT—PIERCING MOTHS

Noctuid fruit piercing moths were much in evidence during August. Trials with the residual insecticides Dieldrin, Endrin and Gamalin were carried out in plots B6 SW and C5 NW at concentrations of half pint, quarter pint and one-eighth pint in 5 gallons of water respectively.

Two methods of assessment were employed. Pierced fruit falls for seven days before and after spraying and pierced fruit falls for seven days after spraying on treated and control plots with trees of comparable size and bearing capacity.

Results were somewhat indeterminate due to the difficulty of distinguishing falls due to different causes, but there was an indication that the total falls were significantly fewer in all of the treated plots but there was no difference between the results of the treatments.

DRIVER ANTS, DORYLUS spp.

Biological studies on these familiar but little understood insects were begun. The queen which has hardly ever been seen even by entomologists was collected from a number of colonies by spraying the ants with Gammalin 20 and excavating alternately. Larvae and pupae were commonly found at a depth of one foot but the queen was usually at least three feet below the surface. A number of queens were sent to the British Museum (Natural History) where they were previously very poorly represented.

It is hoped to obtain sufficient material of all casts to work out the taxonomy of the Genus and solve some vexed biological problems in connection with these important ants. It is noticed for instance that during their frequent moves from one abode to another the ants transport larvae and pupae of workers and soldiers. The immature forms of males are never moved nor is the queen ever transferred. Presumably they remain behind in the old nests but how do they fare and what provision is made for their welfare ? What does their food consist of and how is it stored ? The biology of the queen and males needs to be investigated.

LOCUSTS

There were no reports of locusts invasions of Nigeria and it is of interest to note that the tree-locust *Anacridium moestum* was also comparatively inactive, illustrating the similarity between different kinds of locusts in their response to environmental factors.

MISCELLANEOUS PESTS

The giant cricket *Brachytrypes membranaceous* Drury Gryllidae did considerable execution among cassava seedlings at Moor Plantation, lurking in burrows in the ground by day and cutting down the young plants by night. They were controlled by dusting the nursery beds and surrounds with BHC 0.5 per cent dust.

Nezara viridula L and two other pentatomids appeared in considerable numbers damaging the fruits of breeding cassava. They were likewise controlled with BHC dust.

Adult beetles of *Ootheca mutabilis* Sahl. Galerucidae were again recorded attacking the foliage of cowpea plants at Moor Plantation. They were brought under control by spraying with Gammalin 20.

QUELEA RESEARCH

Research on Quelea birds was continued throughout the year by the Research Fellow attached to the Zoology Department of the University College, Ibadan.

Over the past year several thousands of crop contents of Quelea have been analysed. From the results obtained it is possible to draw a general picture of the seasonal dietary changes and to correlate these with body-weight fluctuations—a measure of the birds' well-being. These studies will be greatly intensified over the coming year but, in order to understand the results that are being gathered, a series of unelaborate aviary experiments must be conducted.

The broad aims of these trials are as follows:—

(*i*) To determine whether the weight changes of birds given abundant food at all times are the same as those undergone by wild birds with a variable food supply.

(*ii*) To establish whether the fat deposits normally built up in the mid-dry season can be built up in the absence of Wild Rice and Guinea Corn—seeds which are taken in Bornu to a large extent at this time of the year.

(*iii*) To evaluate the quantities of food required by caged birds and the changes with the seasons for comparison with the figures obtained for wild birds.

(*iv*) To determine any changes in preference for certain seeds associated with the seasons.

(*v*) To discover the basis for such preferences.

In order to satisfy the first three aims, experiments will be carried out on a stock of about one hundred birds kept in an aviary.

For the food preference experiments, recently captured birds will be used.

STRIGA RESEARCH

Mr C. N. Williams resigned his appointment as research fellow on 30th September, 1960. Mr S. N. C. Okonkwo, a Nigerian has been recruited in his place. Work will continue on investigations into the mode of exchange of food materials between host and parasite to determine at what point the greatest damage to the host occurs.

LIBRARY

A new building was constructed during the period under review but no Librarian was appointed until the end of March 1961.

PUBLICATIONS

Bailey, A. G. and Eijnatten, C. L. M. van.—Corn gray spot caused by *piricularia* grisea. Phytopathology, March 1961, *51* (3) 197-198.

Bates, J. A. R.—Studies on a Nigerian forest soil I. The distribution of organic matter in the profile and in various soil fractions, J. Soil Sci., September 1960, *II* (2), 246-256.

Bates, J. A. R. and Baker, (Mrs) T. C. N. Studies on a Nigerian forest soil II. The distribution of phosphorus in the profile and in various soil fractions. J. Soil Sci., September 1960, *II* (2), 257-265.

Chant, S. R.—Effect of infection with tobacco mosaic and cowpea yellow-mosaic viruses on the growth rate and yield of cowpea in Nigeria, Emp. J. exp. Agric., April 1960, *28* (110), 114-120.

Eijnatten, C. L. M. van and Hill, P. R.—Maize trials on the Accra plains, Ghana. J.W. Afr. Sci. Assoc, August 1960, *6* (2), 142-148.

METEOROLOGICAL STATION MOOR PLANTATION 0703.25B

REPORT ON RAINFALL

JANUARY-DECEMBER 1960

Months	*Rainfall in Inches*	*10 Years Average 1950-1959 in Inches*	*No. of Wet Days*	*Cumulative Total in Inches*
	10.00 a.m.			
January	Nil	0.34	Nil	—
February	0.33	1.12	2	0.33
March	4.54	3.84	8	4.87
April	5.03	5.40	14	9.90
May	7.71	6.15	12	17.61
June	15.04	7.29	19	32.65
July	5.22	5.79	17	37.87
August	6.52	2.56	16	44.39
September ..	9.56	6.39	21	53.95
October	6.30	7.78	20	60.25
November ..	1.11	2.47	6	61.36
December ..	1.09	0.21	4	62.45
TOTAL	62.45	49.34	139	—

METEOROLOGICAL STATION MOOR PLANTATION 0703.25B

REPORT ON RAISED AND SUNKEN EVAPORATION TANKS

JANUARY-DECEMBER 1960

Months	*Raised Tank Evaporation*			*Sunken Tank Evaporation*
	No. of Cups Added	*No. of Cups Withdrawn*	*Evaporation in Inches*	*Evaporation in Inches*
	10.00 a.m.			10.00 a.m.
January	215	—	4.30	4.30
February	272	—	5.77	5.77
March	229	109	6.94*	6.98
April	126	140	4.75	4.75
May	165	258	5.85†	5.93
June	66	449	7.38	7.38
July	97	192	3.32	3.32
August	103	154	5.58	5.58
September	65	366	3.56	3.56
October	81	204	3.84	3.84
November	184	29	4.21	4.21
December	174	38	3.81	3.81
Totals	1,777	1,939	59.31	59.43
Mean	148	162	4.94	4.95

* Rainfall exceeded the tank hence the difference.

† Rainfall exceeded the tank on 30-5-60 hence the difference.

METEOROLOGICAL STATION MOOR PLANTATION (0703.25B)

REPORT ON EVAPOTRANSPIROMETER

JANUARY-DECEMBER 1960

Months	*Mean Screen Maximum* °F	*Mean Screen Maximum* °F	*Mean Dry* °F	*Mean Wet* °F	*Addition In* cc	*Overflow In* cc
	10.00 a.m.		4.00 p.m.		8.00 a.m.	8.00 p.m.
January	92.7	68.1	91.5	75.6	*69,000	46,470
February	96.6	73.5	95.6	75.3	—	—
March	94.3	71.2	92.6	76.5	*46,500	45,510
April	89.3	71.3	89.1	78.0	45,000	46,780
May	89.0	71.4	86.8	78.2	46,500	60,040
June	86.8	71.0	84.2	77.0	*45,000	164,190
July	84.1	70.2	81.7	75.4	46,500	236,250
August	83.7	70.4	81.8	75.7	46,500	59,790
September	86.2	71.0	81.3	75.3	45,000	92,500
October	87.0	70.4	84.5	77.0	46,500	52,650
November	90.7	70.0	88.9	76.5	45,000	29,850
December	90.9	70.0	89.3	76.8	46,500	37,100
Total	1,071.3	848.5	1,047.3	917.3	528,000	871,130
Mean	89.3	70.7	87.3	76.4		79,194

REMARKS

* The addition of water to tank was adjusted from 2,500cc to 1,500cc from 24th January, 1960 onwards, in light of experience of local crops needs.

(2) From 1st February to 13th March, 1960 *NO* records were obtainable owing to excessive heat, radiation and evaporation drying out the soil in the drum.

(3) From 25th March, 1960 the watering period was changed from 5 p.m. to 8.00 a.m.

(4) The drum was not in use for one day (30th June, 1960) owing to exceptional rain causing underground stream to damage drum.

METEOROLOGICAL STATION MOOR PLANTATION 0703.25B

REPORT ON SUNSHINE

JANUARY-DECEMBER 1960

Months	*Duration of monthly Sunshine*	*Mean Duration of Sunshine*
	6.00 a.m. to	6.00 p.m.
January	214.3	6.91
February	220.7	7.61
March	208.3	6.72
April	189.1	6.30
May	229.8	7.41
June	167.7	5.59
July	127.3	4.11
August	94.5	3.03
September	94.7	3.16
October	130.7	4.22
November	228.3	7.61
December	219.3	7.07
Totals	2124.7	69.74
Mean		5.81

Meteorological Station Moor Plantation (0703.25b)

REPORT ON TEMPERATURE DATA

January-December 1960

Months	Mean Maximum °F	Mean Minimum °F	Mean Dry °F	Mean Wet °F	Mean Relative Humidity %	Mean Grass Minimum °F	Mean Earth 1 ft. °F	Mean Earth 4 ft. °F	Mean Dew point °F	Mean Vapour Pressure MBS	Mean Anemometer Wind Runs Miles	Mean Water Maximum	Mean Water Minimum °F	Mean Dry °F	Mean Wet °F	Mean Relative Humidity %	Mean Earth 1 ft oF	Mean Anemometer Wind Runs Miles	Mean Dew point	Mean Vapour Pressure MBS
	10.00 a.m.													4.00 p.m.						
January ..	92.7	68.1	79.4	72.0	69.0	65.8	86.2	85.7	68.0	24.2	40.03	88.2	66.0	91.5	75.6	46.0	90.2	40.14	67.0	23.3
February ..	96.6	73.5	82.4	76.0	73.7	71.6	90.4	88.2	73.0	27.9	54.12	92.0	69.7	95.6	75.3	38.0	91.8	54.18	65.0	20.9
March ..	94.3	71.2	81.8	75.8	75.2	70.7	88.6	89.4	73.0	27.8	61.53	92.9	68.6	92.6	76.5	46.7	90.7	62.07	68.6	24.1
April	89.3	71.3	80.5	76.0	80.9	71.0	86.4	87.7	74.1	28.8	46.92	93.1	69.9	89.1	78.0	65.8	88.3	46.10	73.9	28.7
May	89.0	71.4	81.1	76.6	80.4	70.7	86.7	87.5	74.0	29.2	44.01	96.0	70.5	86.8	78.2	67.8	88.6	43.93	74.5	29.1
June	86.8	71.0	78.6	74.7	83.3	70.2	84.5	86.5	73.0	27.2	40.20	90.2	69.3	84.2	77.0	71.6	86.2	40.51	73.9	28.5
July	84.1	70.2	76.5	73.1	84.6	69.0	82.4	84.0	71.5	26.3	50.79	85.7	68.1	81.7	75.4	74.3	83.3	49.14	72.5	27.2
August	83.7	70.4	76.0	72.8	85.4	69.5	81.7	82.9	73.6	26.1	52.77	85.3	67.8	81.8	75.7	75.0	82.5	53.32	73.0	27.7
September ..	86.2	71.0	77.2	74.0	85.3	70.5	81.5	82.7	72.5	27.2	42.46	87.4	68.6	81.3	75.3	77.3	82.9	42.73	73.2	27.8
October	87.0	70.4	78.9	75.1	80.4	69.8	82.2	83.0	73.4	28.1	33.34	88.7	68.2	84.5	77.0	70.4	83.8	32.96	73.7	28.4
November ..	90.7	70.0	80.6	75.8	79.8	68.4	84.7	84.7	73.7	28.4	22.93	91.5	69.6	88.9	76.5	55.3	86.6	22.74	70.2	25.4
December ..	90.9	70.0	79.6	74.0	76.6	67.7	85.1	85.6	71.1	26.8	25.53	89.6	69.0	89.3	76.8	55.5	86.9	26.16	70.8	26.0
Totals ..	1071.3	848.5	952.6	895.9	954.6	834.9	1020.4	1028.1	870.9	328.0	514.63	1080.6	825.3	1047.3	917.3	743.7	1041.8	513.98	856.3	317.1
Mean ..	89.3	70.7	79.4	74.7	79.6	69.6	85.0	85.7	72.6	27.3	42.89	90.1	68.8	87.3	76.4	62.0	86.8	42.83	71.4	26.4

APPENDIX 1

METEOROLOGICAL DATA FOR BADEGGI RICE RESEARCH STATION
1960

	Rainfall (inch) Badeggi	*Average Rainfall in Bida (30 years)*	*Mean Relative Humidity* (%) 0900 GMT	*Mase Temp.* (°F)	*Min. Temp.* (°F)	*Mean Temp.* (°F)
January	0.00	0.12	48.6	93.1	63.5	78.3
February	0.07	0.30	44.6	97.3	64.1	80.7
March	3.17	1.10	52.2	98.0	72.0	85.0
April	6.43	2.94	72.9	92.0	75.0	83.5
May	4.62	5.94	73.3	93.0	75.0	84.0
June	9.77	7.28	80.1	90.0	73.0	81.5
July	10.89	8.12	81.7	87.0	73.0	80.0
August	4.55	8.20	81.7	87.0	74.0	80.5
September	11.13	10.10	84.0	87.0	73.0	80.0
October	3.77	4.36	77.1	90.0	73.0	81.5
November	0.00	0.30	63.1	93.0	67.0	80.0
December	0.07	0.00	63.5	94.0	69.0	81.5
TOTAL	54.47	48.76				

DPDL 2039(64)/365/2,050